PROCEEDINGS

EPA SCIENCE FORUM 2005:
Collaborative Science for Environmental Solutions

May 16-18, 2005

United States Environmental Protection Agency
Ronald Reagan Building and International Trade Center
Washington, DC

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Acronyms

ACWI	Advisory Committee on Water Information
AGWA	Automated Geospatial Watershed Assessment
AK	*Acanthamoeba* Keratitis
AMI	Advanced Monitoring Initiative
AOAC	Association of Official Agricultural Chemists
AQI	Air Quality Index
ASDWA	Association of State Drinking Water Administrators
ASTM	American Society for Testing and Materials
ATtILA	Analytical Tools Interface for Landscape Assessments
BASINS	Better Assessment Science Integrating Point and Nonpoint Sources
C3	command, control, and communication
C4	command, control, communication, and computer
CAA	Clean Air Act
CCL	Contaminant Candidate List
CDC	Centers for Disease Control and Prevention
CDX	Central Data Exchange
CREM	Council on Regulatory Environmental Modeling
CRSSP	Commercial Remote Sensing Space Policy
CWA	Clean Water Act
DGINFSO	Directorate General for Information, Society, and Media
DNA	deoxyribonucleic acid
DOE	Department of Energy
DOH	Department of Health
EEA	European Environment Agency
EIMS	Environmental Information Management System
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
EPIC	Environmental Photographic Interpretation Center
ESAR	Environmental Sampling, Analysis, and Results
ESTE	Environmental and Sustainable Technology Evaluation
ETV	Environmental Technology Verification

Acronyms (continued)

EU	European Union
FCS	Fire and Climate Society
GEMET	General Multilingual Environmental Thesaurus
GEOSS	Global Earth Observation System of Systems
GIS	geographic information system
GMES	Global Monitoring for Environment and Security
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory
IBM	International Business Machines Corporation
ICT	information and commercial technology
IEOS	Integrated Earth Observation System
ISO	International Standardization Organization
KINEROS	Kinematic Runoff and Erosion
LEV	low-emission vehicle
LIDAR	light detection and ranging
MODIS	Moderate Resolution Imaging Spectroradiometer
MSA	Metropolitan Statistical Area
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NBII	National Biological Information Infrastructure
NCEA	National Center for Environmental Assessment
NCER	National Center for Environmental Research
NEEAR	National Epidemiological and Environmental Assessment of Recreational
NEMI	National Environmental Methods Index
NEPA	National Environmental Policy Act
NERL	National Exposure Research Laboratory
NESCAUM	Northeast States for Coordinated Air Use Management
NGA	National Geospatial-Intelligence Agency
NGO	non-governmental organization
NHEERL	National Health and Environmental Effects Research Laboratory
NIH	National Institutes of Health
NOAA	National Oceanic and Atmospheric Administration

Acronyms (continued)

NPS	National Park Service
NRMRL	National Risk Management Research Laboratory
NSF	National Science Foundation
OAQPS	Office of Air Quality Planning and Standards
OEI	Office of Environmental Information
OGSA	Open Grid Services Architecture
OIA	Office of International Affairs
OIC	Office of Information Collection
OMB	Office of Management and Budget
ORD	Office of Research and Development
OSWER	Office of Solid Waste and Emergency Response
OWOW	Office of Wetlands, Oceans, and Watersheds
PAH	polycyclic aromatic hydrocarbon
PATCH	Program to Assist in Tracking Critical Habitat
PCR	polymerase chain reaction
PM	particulate matter
PSI	Pollutant Standards Index
QPCR	quantitative polymerase chain reaction
RARE	Regional Applied Research Effort
RCRA	Resource Conservation and Recovery Act
REMAP	Regional Environmental Monitoring and Assessment Program
RSIT	Regional Science Integration Team
SDWA	Safe Drinking Water Act
STAR	Science to Achieve Results
STORET	Storage and Retrieval
SWAT	Soil and Water Assessment Tool
TCLP	Toxicity Characteristic Leaching Procedure
TEQ	toxic equivalency
TMDL	Total Maximum Daily Load
TRI	Toxics Release Inventory
TSE	Technologies for a Sustainable Environment

Acronyms (continued)

TURA	Toxics Use Reduction Act
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WACAP	Western Airborne Contaminants Assessment Project
WRApp	Window to Regional Applications

Executive Summary

The Environmental Protection Agency (EPA) presented the *2005 Science Forum: Collaborative Science for Environmental Solutions* on Monday, May 16, through Wednesday, May 18, 2005, in Washington, DC. This *Science Forum* highlighted EPA's scientific accomplishments, showcased EPA's commitment to quality science, and demonstrated, through examples, the use of science in decisionmaking and policymaking. The *Science Forum* also provided an opportunity for dialogue and interaction among EPA scientists, clients, stakeholders, and colleagues with over 1,000 attendees at this event, including EPA program, research, and regional staff; members of other federal and international agencies; the scientific community; and the public.

The *Science Forum* consisted of a full day session of plenary speakers including an educational session on international, national, and regional remote sensing initiatives and three two-day breakout sessions. Each breakout session examined a theme area for specific EPA organizations—the Office of Environmental Information (OEI), the Office of Research and Development (ORD), and the EPA Regions. The *Science Forum* included over 230 posters on current research activities and speaker-specific topics, EPA scientists/engineers present to discuss their research efforts, and 16 exhibits/demonstrations of EPA and other federal agency scientific and educational programs.

Plenary Session

The purpose of this session was to provide plenary addresses on global and national environmental collaborations. The Director of the National Exposure Research Laboratory (NERL), Dr. Gary Foley, opened the plenary session of the *Science Forum* and discussed EPA commitment to science and collaboration. The Acting Assistant Administrator for ORD, Dr. Timothy Oppelt, introduced the Director of the United States Geological Survey (USGS), who discussed the Global Earth Observation System of Systems (GEOSS), an international collaboration to make observation data interoperable worldwide to provide environmental and societal benefits. The Chief of Staff for OEI, Mr. William Sonntag, introduced the Scientific Officer for Risk Management with the European Commission, Dr. Karen Fabbri, who presented European Commission research, information management, and collaboration efforts in the areas of disaster management, risk management, and the environment. The Deputy Regional Administrator for EPA Region 3, Mr. Tom Voltaggio, introduced the Director of the Environmental Assessment and Innovation Division in EPA Region 3, Mr. John (Randy) Pomponio, who discussed efforts taken at the regional level to improve science utilization and examples of how ORD science resulted in positive environmental outcomes.

GEOSS and Remote Sensing Technology

Wendy Blake-Coleman (with OEI), Terrence Slonecker (with NERL), and John Lyons (with NERL) led this session addressing remote sensing technologies and GEOSS support activities. David Jennings, with NERL, discussed indirect and direct methods of remote sensing to analyze water quality. Carolyn Offutt, with the Office of Solid Waste and Emergency Response, discussed the use of remote sensing for historical site analysis, emergency response, and visualization. Dorsey Worthy, with NERL, discussed the use of remote sensing to perform air quality assessments under the BlueSkyRAINS project, a multi-agency collaborative effort to interpret data, make predictions, perform assessments, and provide societal benefits. Barry Feldman, with EPA Region 6, discussed EPA efforts in response to a Congressional request to construct a "one-stop-shop" for remote sensing projects. Brenda Smith, with OEI, discussed enterprise efforts to collect and identify the variety of geospatial data generated and utilized across EPA, policy efforts to streamline the process, and methods for data storage and retrieval. Tom Cecere, with the

USGS, discussed the U.S. Commercial Remote Sensing Space Policy, agency roles, desired outcomes, and potential benefits. Terrence Slonecker, with NERL, discussed an EPA initiative to examine the Caribbean area that can serve as model of what a GEOSS project might demonstrate in terms of societal benefits. Gary Foley, Director of NERL, discussed GEOSS, its benefits, and associated international and national efforts including plans, partnerships, and requirements. Steve Young, with OEI, presented an overall view of the EPA role in GEOSS. Ed Washburn, with ORD, discussed the organization of GEOSS support within EPA.

Office of Environmental Information Track

This two-day session focused on the use of computing systems and other tools to facilitate data acquisition and analysis, the use of environmental information to make decisions, national water quality monitoring initiatives, standards that facilitate data exchange across organizations, environmental indicators for decisionmaking, management of environmental terminology, and future information system directions within EPA. A key theme in these presentations is the importance of making disparate data and tools available to diverse users and decisionmakers through the creation of interoperable systems with appropriate data documentation and common terminologies.

Managing Scientific Data for Effective Interactive Analysis and Decisionmaking. Robin Gonzalez, with the EPA National Computer Center, led this session addressing the use of advanced computing and information technology applications to analyze large data sets and large volumes of information in a useful way. Robin Gonzalez discussed EPA efforts to better understand the relationship between environmental triggers and genetic susceptibility in order to better predict and project the effects for better decisionmaking. Dr. Andrew Grimshaw, with the University of Virginia, discussed the use of grid computing to share data and computational resources among different organizations and provided examples of the application of this technique to the life sciences. Larry Proctor, with the International Business Machines Corporation's Almaden Research Center, discussed the use of advanced text analytics to analyze concepts in unstructured information (e.g., documents) to derive information of interest from context and how this technique can reduce the time required to assemble and analyze information as well as enable the discovery of nonobvious relationships. Grant Heffelfinger, with Sandia National Laboratories, discussed the use of hyperspectral imaging to obtain high throughput experimental data that, with the use of algorithms, can produce high fidelity measurements necessary to develop predictive models, and provided examples of the application of this technique to the life sciences. Todd Plessel, with Lockheed Martin, discussed the challenges encountered in visualization and assimilation of large volumes of data in multi-data sets, and provided examples of the data requirements and effort involved in creating both single use and turn-key applications.

Environmental Information for Decisionmaking: What Does the Science Say? Matthew Clark, with the National Center for Environmental Research (NCER), led this session addressing the use of environmental information to make decisions, reduce releases to the environment, affect consumer choices, and protect health by promoting changes in behavior. Matthew Clark discussed ORD efforts to look at linkages between science and behavior to understand how people view or act on certain types of information. Gail Froiman, with OEI, discussed the use of Toxics Release Inventory (TRI) information by industry, states, tribes, nongovernmental organizations, financial services, and international organizations to reduce releases or achieve other environmental or socioeconomic benefits. Lori Bennear, with Duke University, discussed the use of TRI data in evaluating performance at the national and state level, and the impacts of reporting thresholds on data interpretation. Julie Hewitt, with the National Center for Environmental Economics, discussed new testing methods for health-related contamination at beaches, their impact on the timing of notifications for beach closure and re-opening, and associated health benefits. Carol Mansfield, with Research Triangle Institute International, discussed findings from a recent study that documented the use of the ozone alert system to make behavior changes on a day-to-

day basis with resultant improvements in health, and how this finding affects traditional cost-benefit analysis through possible underestimation of health impacts and benefits of air quality improvements.

Collaboration and Comparability in National Water Quality Monitoring Programs. Chuck Spooner, with the Office of Wetlands, Oceans, and Watersheds (OWOW), led this session addressing diverse national water quality monitoring initiatives and the collaborations and challenges involved in these activities and in the data analysis. Chuck Spooner, with OWOW, discussed efforts to design the National Water Quality Monitoring Network and to integrate data from multiple monitoring systems and programs at the national, state, and regional level that are conducted by multiple federal and state organizations. LeAnne Astin, with the Interstate Commission on the Potomac River Basin, discussed activities of the Water Quality Data Elements Work Group to define water quality data elements, monitoring program design to promote data comparability, and data documentation requirements to improve the exchange of information of comparable quality across water quality monitoring programs. Laura Gabanski, with OWOW, discussed the national Wadeable Stream Assessment to produce a statistically valid assessment of the nation's waters and associated data comparability studies. Eric Vowinkel, with the USGS, discussed the content and capabilities of the National Environmental Methods Index (a web-accessible compilation of analytical methods) and its use to identify and compare analytical methods for specific purposes including validation of historical data.

Use of Exchange Network and Data Standards to Improve and Encourage the Exchange of Data. Andrew Battin, with the OEI Information Exchange and Services Division, led this session addressing exchange networks at the national, regional, and state level, and the data standards that facilitate data sharing. Andrew Battin, with OEI, discussed the development of the EPA Exchange Network to provide data flow between the states/tribes and EPA. Oscar Morales, with the OEI Collection Strategies Division, discussed the development of the Environmental Sampling, Analysis, and Results data standard and its components. Mitch West, with the Oregon Department of Environmental Quality, discussed the development of the Pacific Northwest Water Quality Data Exchange and its components to provide multi-state access to a comprehensive collection of water quality data for the Pacific Northwest to address issues pertaining to salmon. Deborah Stewart, with the Washington Department of Ecology, discussed several information exchange approaches implemented to improve inter-Department and inter-state information exchange.

Anatomy of an Indicator. Heather Case, with OEI, led this session addressing the complexity, applications, and challenges in developing and applying environmental indicators. Denice Shaw, with ORD, discussed the use of indicators and indices in decisionmaking and associated issues of scale. Richard Wayland, with the Office of Air Quality Planning and Standards (OAQPS), discussed the history and evolution of the Air Quality Index as an indicator of public health impacts enabling individuals to take specific protective actions. Randy Mosier, with the Maryland Department of the Environment, discussed the dissemination and use of air quality information to elicit action at the local level to protect health and reduce air pollution. Jay Messer, with the National Center for Environmental Assessment (NCEA), discussed the challenges of scale in interpreting indicator information and using indicators in decisionmaking.

Language and Metadata Management International Collaborative Projects. Larry Fitzwater, with the OEI Data Standards Branch, led this session addressing metadata, environmental terminology, and standards applicable to development efforts in these areas. Larry Fitzwater, with OEI, discussed the definitions and use of metadata, concept management, content management, the semantic web, and the requirements of the ISO 11179 standard that define all of these activities. Gail Hodge, with Information International Associates, Inc., discussed the international ecoinformatics initiative and the challenges associated with developing a common terminology for environmental data and to address metadata.

David Stanners, with the European Environmental Agency, discussed European efforts to develop an environmental data exchange for 25 countries.

Enterprise Architecture in Action: Analysis and Tools for Decisionmaking in the Regions and States. Megan Quinn, with OEI, led this session addressing the overall architecture and various information technology systems being developed at EPA to facilitate the exchange and analysis of scientific and other data. John Sullivan, with OEI, and Brenda Young, with ORD, discussed the creation of an enterprise architecture to connect all of the activities being conducted by EPA to more efficiently leverage work, applications, and platforms. Jacques Kapuscinski, with the Office of Resources Management Administration in ORD, discussed the EPA Science Portal that is being developed to support ORD and the EPA Regions in accessing research data, models, tools, and other information. Ming Chang, with OEI, discussed the Window to Regional Applications that is being developed to provide access at the regional and state level to tools, data, and decision support systems with an emphasis on water programs. Elsie Sunderland, with NERL, discussed the creation of a knowledge base of all models used at EPA and a model selection tool to assist users in identifying and selecting models appropriate to their needs.

Office of Research and Development Track

This two-day session focused on research activities receiving high recognition through the Scientific and Technology Achievement Awards, green chemistry and green engineering, the impacts of airborne contamination on high elevation National Parks, spatial analysis tools for decisionmaking, ecosystem restoration, technology verification, and climate change impacts on species, ecosystems, and resources. A key theme in these presentations is the role of science in developing the understanding necessary to make decisions on environmental matters, reduce pollution, and restore resources.

25th Anniversary of Scientific and Technological Achievement Awards (Session 1). Tom Barnwell, with NCER, led this session addressing the Scientific and Technology Achievement Awards program with examples of award-winning research. Deborah Corey Schlechta, Chair of the Science Advisory Board's Scientific and Technological Achievement Awards Panel, discussed the role of the Science Advisory Board with these awards, the review and recommendation process, and ideas for the future. Scott Leibowitz, with the National Health and Environmental Effects Research Laboratory (NHEERL), discussed impacts of a U.S. Supreme Court decision on how to define the waters of the U.S. and associated research into understanding isolated wetlands. Christian Andersen, with NHEERL, discussed aboveground and below ground ecosystem complexity, the findings of ozone effects on soil organisms and carbon allocation, and the scaling of plant-level responses to ecosystem level. Douglas Kendall, with the National Enforcement Investigations Center in the Office of Enforcement and Compliance, discussed the challenges of toxicity testing to replicate landfill conditions drawing on a case study involving the treatment of brass foundry waste with iron to reduce lead levels.

25th Anniversary of Scientific and Technological Achievement Awards (Session 2). Tom Barnwell, with NCER, led this session addressing additional examples of research receiving a Scientific and Technological Achievement Award. William Farland, Acting Deputy Assistant Administrator for Science, discussed the awards, criteria for eligibility, award statistics, the selection process, and award recognitions. Andrew Kligerman, with NHEERL, discussed the mechanisms for arsenic to enter cells and cause cancer-inducing damage at the genetic level. Nena Nwachuku, with the Office of Science and Technology, discussed the statutory requirements to investigate amoebic pathogens and the understanding of infection pathways for *Acanthamoeba* that led to a decision to not regulate this pathogen. Sherry Selevan, with NCEA, discussed potential relationships between blood level concentrations and delays in the onset of puberty in girls of different genetic backgrounds.

Informing the Next Decade of Green Chemistry and Green Engineering Research. Diane Bauer, with NCER, led this session addressing the next decade of green chemistry and green engineering research. Douglas Young, with the National Risk Management Research Laboratory (NRMRL), discussed EPA experience with green reactor design, solvent strategies, catalyst design, membrane technologies, and absorbents as well as extramural expertise and future directions. Thomas Theis, with the University of Illinois at Chicago, discussed the concept of industrial ecology and provided an example of the use of soybean oil to replace mineral oil in industrial processes. Richard Engler, with the Office of Pollution Prevention and Toxics, discussed the definition, founding principles, demonstrated benefits, and measurable results of green chemistry. Delcie Durham, with the National Science Foundation, discussed a collaborative research program with EPA on environmentally benign technologies and green manufacturing with examples of funded research activities.

A Large Scale, Interagency Science Project to Evaluate the Impacts of Airborne Contaminants in the West. Dixon Landers, with NHEERL, led this session addressing multi-organization collaboration to assess the presence and impacts of airborne contaminants at high elevations within U.S. National Parks. Dixon Landers, with NHEERL, discussed the purpose, objectives, research questions, study sties, and timelines for this project. Chris Shaver, with the National Park Service, discussed the need to understand the presence and impacts of persistent organic pollutants in the National Parks and efforts underway to address this need. Donald Campbell, with the USGS Colorado Water Science Center, discussed the role of the USGS in sampling activities for this project and the challenges of conducting snow pack sampling in high elevation conditions. Staci Simonich, with Oregon State University, discussed academic contributions involving the analysis of samples and resulting data to understand the presence and variation in levels of pesticides in the National Parks.

Spatial Analysis Tools and Applications for Environmental Assessments and Management. Luis Fernandez, with the Office of International Affairs (OIA), led this session addressing spatial analysis tools and their application to environmental assessment, decisionmaking, and management. Luis Fernandez, with OIA, discussed the formation of a work group on spatial analysis tools for landscape ecology to share ideas, provide beta testing, and share research. Nathan Schumaker, with NHEERL, discussed a simulation model to help EPA predict wildlife populations in support of wildlife risk assessments. Harvey Simon, with EPA Region 2, discussed a tool to support EPA evaluations of environmental impact assessments and to simplify the process for screening proposed projects. Richard Zdanowicz, with EPA Region 5, and Dreux Watermolen, with the Wisconsin Department of Natural Resources, discussed the Midwest Spatial Decision Support System Partnership and a series of regional decision support tools for impact analysis. Donald Ebert, with NERL, discussed the history, architecture, benefits, and future plans for a landscape analysis tool supporting water quality and ecology assessments. David Goodrich, with the USDA Southwest Watershed Research Center, discussed a GIS tool for watershed modeling that investigates the impacts of land use and land cover change on runoff, erosion, and water quality at multiple scales.

Sustainable Solutions for Restoring Degraded Watersheds and Riparian Ecosystems: Implementation, Evaluation, and Amelioration. Joseph Williams, with NRMRL, led this session addressing ecosystem restoration research, tools, and community-level actions to understand and restore watersheds and riparian ecosystems. Joseph Williams, with NRMRL, discussed the EPA framework for ecosystem restoration research and collaborations with other agencies and organizations. Jennifer Newland, with the Canaan Valley Institute, discussed research efforts and goals of the Highlands Action Program as well as the framework for a spatial multicriteria tool. Jeanne Chambers, with the U.S. Forest Service, discussed an interdisciplinary effort with EPA to understand and restore a riparian ecosystem in Nevada. Donald Outen, with the Baltimore County Department of Environmental Protection and Resource Management, discussed county-level initiatives in ecosystem research, the need for collaborative research, the use of EPA research, and case studies of ecosystem restoration efforts. Paul Mayer, with NRMRL, discussed

the impacts of stream restoration projects on water quality and a case study involving restoration of Minebank Run in Maryland.

The Environmental Technology Verification (ETV) Program: Collaborating for Outcomes. Teresa Harten, with NRMRL, led this session addressing the ETV program and example verification activities. Evelyn Hartzell, with NRMRL, discussed issues associated with diesel-powered vehicle engines and verification activities for diesel retrofit technologies to reduce emissions. Dennis Johnson, with the Office of Transportation and Air Quality, discussed the National Clean Diesel Campaign and its mission to control mobile sources of air pollution. Thomas Kelly, with Battelle, discussed ammonia emissions and their role in the formation of fine particulate matter, and verification activities for new types of ammonia monitors. Bruce Bartley, with NSF International, discussed the development of testing protocols for drinking water research. Jeff Adams, with NRMRL, discussed research on arsenic removal technologies to address new limits on arsenic in drinking water. Ray Frederick, with NRMRL, discussed collaborative activities with the U.S. Coast Guard to develop a Ballast Water Treatment Protocol. Kathleen Moore, with the U.S. Coast Guard, discussed ballast water management requirements and ongoing research activities.

Public-Private Partnerships to Understand, Assess, and Adapt to Climate Change. Joel Scheraga, with ORD, led this session addressing collaborative efforts to predict and mitigate impacts of climate change on ecosystems, resource planning/management, policymaking, and decisionmaking. Dan Loughlin, with NRMRL, discussed activities in support of the U.S. Global Change Research Program, and Gary Kleiman, with the Northeast States for Coordinated Air Use Management, discussed applications of an energy sector model to assess future air pollutant reductions achievable from potential transportation measures. William Fisher, with NHEERL, discussed research efforts to understand stressors of coral reefs and visualization tools to assist in measuring coral population changes. Barbara Morehouse, with the University of Arizona, discussed a predictive model for wildfires and resulting value impacts to support planning and decisionmaking. John Furlow, with NCEA, discussed impacts of climate change on water systems and combined sewer overflows. Arnold Vedlitz, with Texas A&M University, discussed efforts to understand how decisionmakers obtain and use scientific information to improve information dissemination and utility.

Regional Track

This two-day session focused on regional efforts to face the challenges of marine ecosystem health and restoration, mercury transport and bioaccumulation in the environment, water quality assessment, old and new pathogens, and air toxics. A key theme in these presentations is that the best use of limited research resources to obtain the information needed for decisionmaking is through collaboration.

How Healthy Are Our Marine Environments? Jonathan Garber, with NHEERL, led a session addressing the assessment and management of marine environments. Hal Walker, with NHEERL, discussed the collaboration between the National Coastal Assessment Program, states, EPA Regions, tribes, and academia to develop tools for coastal ecosystem assessment and evaluation. David Turn, with EPA Region 1, discussed the need to develop real-time bacteria detection methods for timely decisions on beach closures. Carin Bisland (with EPA Region 3), Peter Clagget (with the USGS), and Laura Jackson (with NHEERL), discussed issues of urban sprawl and impacts on the Chesapeake Bay. Joan Cabreza, with EPA Region 10, discussed invasion pathways for exotic species and the need to develop a pathway analysis and screening tool. Mike Blum, with NERL, discussed the spread of invasive species via secondary introductions. Daniel Kluza, a postdoctoral fellow with NCEA, discussed the proposed introduction of the Asian oyster into the Chesapeake Bay. Treda Smith, with the Office of Science and Technology, provided an overview of the Regional Methods Program and discussed collaborations with

the Biological Advisory Committee. John Johnston, with NERL, discussed risk in coastal environments and multimedia exposure modeling.

The Transport and Bioaccumulation of Mercury in the Environment. Patti Lynne Tyler, with EPA Region 8, led a session addressing the transport and bioaccumulation of mercury in the environment. John Ackermann, with EPA Region 4, discussed a conceptual model used by EPA to examine environmental mercury and multi-media research on mercury in the Everglades. Dale Hoff, with EPA Region 8, discussed the efforts to identify the source of mercury contamination in fish on the Cheyenne River Sioux Tribal Reservation and risk management measures taken to protect sensitive populations. John Johnston, with NERL, discussed the studies and tools that provided the scientific data underlying the Clean Air Mercury Rule.

Pathogen Challenges: New Pathogens, Old Pathogens but New Challenges. David Macarus, with EPA Region 5, led a session addressing the challenges presented by new and old pathogens. Jafrul Hasan, with the Office of Science and Technology and the National Homeland Security Research Center, discussed the pathogen challenges EPA is facing and future research needs to meet these challenges. Fran Kremer (with NRMRL), Susan Mooney (with EPA Region 5), and Wendy O'Brien (with EPA Region 8), discussed chronic wasting disease and waste disposal methods. Mark Rodgers, with NRMRL, discussed the Microbial Source Tracking Guide and applications to identify the origin of fecal pollution. Tim Wade, with NHEERL, discussed the National Epidemiological and Environmental Assessment of Recreational Water Study of beach contamination and methods to more quickly provide analytical results for decisionmaking. Michael Kramer, with EPA Region 2, discussed the Ambient Sampling Monitoring Program to evaluate the impacts of pesticide applications to control West Nile virus in New York.

Restoration Actions and Salmon Productivity in Pacific Northwest Watersheds. Derek Poon, with EPA Region 10, led a session on restoration actions and efforts to understand salmon productivity in the Pacific Northwest. Robert Bilby, with the Weyerhaeuser Company, discussed the reasons for monitoring watersheds in the Pacific Northwest as a means to address declining Pacific salmon populations. William Ehinger, with the Washington Department of Ecology, discussed the design of the Intensively Monitored Watersheds Program, which includes before and after assessments on both controlled and impacted areas, hierarchical monitoring schemes at different spatial scales, and hypothesis-driven monitoring and research. Christopher Jordan, with NOAA, discussed studies of large watersheds containing Chinook salmon.

Using Landscape Tools to Assess Vulnerability. Brenda Groskinsky, with EPA Region 7, led a session addressing the use of landscape tools to assess water quality vulnerability. Jaci Ferguson, with EPA Region 7, discussed the need to develop a landscape analysis tool to address issues of increasing pollution in the Upper White River Basin in Arkansas and Missouri. Ricardo Lopez, with NERL, discussed the development of water quality indicators to assess water quality vulnerability in the Upper White River Basin.

More than Just Hot Air: Collaborative Approaches to Cleaning Up Air Toxics Locally. Mike Callahan, with EPA Region 5, led a session addressing collaborative efforts at the local level to clean up air toxics. Deirdre Murphy, with OAQPS, discussed challenges faced by EPA with air toxics. Sean Hogan, with EPA Region 9, discussed the challenges faced by EPA Region 9 regarding air toxics, the need for accurate air emissions data, and research on dioxin emissions from wood stoves and emissions from commercial aircraft. Barry Feldman, with EPA Region 6, discussed the use of remote sensing to identify, characterize, and manage air emissions. Jeff Yurk, with EPA Region 6, discussed some of the actions that EPA Region 6 is taking to link toxic emissions to human health effects and collaborative activities with the Centers for Disease Control and Prevention.

Section I: Overview

The Environmental Protection Agency (EPA) presented a *Science Forum* at the Ronald Reagan Building and International Trade Center in Washington, DC, on Monday, May 16, through Wednesday, May 18, 2005. The *EPA 2005 Science Forum: Collaborative Science for Environmental Solutions* was an opportunity to showcase the activities of EPA and other organizations in key areas of environmental research and to spotlight new initiatives and recent successes. As the fourth in a series of annual events, this *Science Forum* built upon the first three Agency-wide *Science Forums* held in May 2002, May 2003, and June 2004, and was co-sponsored by the Office of Research and Development (ORD), the Office of Environmental Information (OEI), and EPA Region 3.

The *Science Forum* highlighted selected high priority topics and EPA's scientific accomplishments, showcased EPA's commitment to quality science, and demonstrated, through examples, how science influences Agency decisions. The *Science Forum* also provided an opportunity for dialogue and interaction among EPA scientists, partners, clients, stakeholders, and colleagues with over 1,000 attendees at this event. Attendees included EPA program, research, and regional staff; members of other federal and international agencies; stakeholders; the scientific community; and interested members of the public. The *Science Forum* included over 230 posters addressing current research activities and specific topics addressed by speakers, discussions of research efforts by EPA and external scientists and engineers, and 16 exhibits of scientific and educational programs at EPA and other federal agencies.

Director of the National Exposure Research Laboratory (NERL), Dr. Gary Foley, opened the plenary session of the *Science Forum* noting how strong science is a key component of the EPA environmental decisionmaking process and providing an overview of the *Science Forum* themes of collaborative solutions, meeting challenges, partnering to protect human health and the environment, and healthy communities and ecosystems. Other plenary speakers provided highlights of international and national efforts to develop information systems to share and analyze data on a global or regional scale to improve decisionmaking and societal benefits; European efforts to collect and evaluate information from 30 countries to enhance environmental risk, disaster, and emergency management; and EPA regional efforts to use science to achieve measurable outcomes in the protection of wildlife, streams, and human health. The opening day session also included an educational session on remote sensing initiatives to address land, water, ocean, and air quality at the global, national, and regional levels.

Three two-day breakout sessions each examined a theme area for specific EPA organizations—the Office of Environmental Information (OEI), the Office of Research and Development (ORD), and the EPA Regions. The audience had an opportunity in each session to ask questions of the speakers. Poster sessions followed the plenary session and each breakout session addressing session-specific and related topics. EPA engineers and scientists were available at these poster sessions to provide additional information and to address attendee questions.

Section II: Plenary Session

Monday, May 16, 2005

The purpose of this session on the first day of the meeting was to provide plenary addresses on national and international collaboration on environmental research and information systems, partnering to protect human health and the environment, and the value and use of science in creating environmental outcomes. These addresses introduced the three topical tracks for the next two days: research and development, environmental information, and regional initiatives.

The Director of NERL, Dr. Gary Foley, opened the plenary session of the *Science Forum* and discussed EPA commitment to science and collaboration. The Acting Assistant Administrator for ORD, Dr. Timothy Oppelt, introduced the Director of the United States Geological Survey (USGS), who discussed international collaborations to make observation data interoperable worldwide to provide environmental and societal benefits. The Chief of Staff for OEI, Mr. William Sonntag, introduced the Scientific Officer for Risk Management with the European Commission, Dr. Karen Fabbri, who presented European Commission research, information management, and collaboration efforts in the areas of disaster management, risk management, and environment. The Deputy Regional Administrator for EPA Region 3, Mr. Tom Voltaggio, introduced the Director of the Environmental Assessment and Innovation Division in EPA Region 3, Mr. John (Randy) Pomponio, who discussed efforts taken at the regional level to improve science utilization and examples of how ORD science is applied to achieve positive and measurable environmental outcomes.

Opening Remarks

Dr. Gary Foley, Director of NERL, opened the Plenary Session and welcomed all the attendees to this fourth annual EPA-wide *Science Forum: Collaborative Science for Environmental Solutions*. Dr. Foley also acknowledged the efforts of ORD, OEI, and EPA Region 3 in developing this event.

The EPA *Science Forum* is a showcase of EPA's commitment to science and provides an opportunity to demonstrate to the stakeholders and the public how strong science is a key component of the EPA environmental decisionmaking process. The themes this year are collaborative solutions, meeting challenges, partnering to protect human health and the environment, and healthy communities and ecosystems.

Environmental Collaborations: Nationally and Across the Globe

Dr. Gary Foley, Director of NERL, introduced Dr. Timothy Oppelt, Acting Assistant Administrator for ORD, who introduced the three plenary sessions representing international, national, and regional collaborations involving research, environmental information, and measuring environmental outcomes.

Global Earth Observation System of Systems

Dr. Timothy Oppelt, Acting Assistant Administrator for ORD, introduced Dr. Charles Grout, Director of the USGS, who discussed the international collaborations to acquire and understand global data to achieve environmental and societal benefits.

The Global Earth Observation System of Systems (GEOSS) effort brings together a band of national and international organizations to understand this planet on a systems basis, how the systems that do not recognize national boundaries operate, and how important science and technology are to achieving this understanding. This is important to those who use these products to make decisions about things that are important to society, such as the environment in which we live and within which we understand our health and resource challenges. Shortcomings that led to this effort included data not being acquired on the global scale necessary, monitoring infrastructures being eroded and not being replaced, spatial and temporal gaps in data sets, and inadequate data integration and interoperability. In addition, there were concerns about data continuity for long-term understanding of the environment and environmental factors, the need for certainty about data collection and distribution, and the need for systems to amass the data and transform the data into useful information.

GEOSS is intended to coordinate existing systems into a distributive system rather than bring all existing systems into one system. There are thousands of data collection systems around the world that are independent and are not linked together, including space-based, aircraft-based, and *in situ* capability; commonly the data sets are not compatible. The key to GEOSS is the ability to facilitate data exchange to support interpretation of the data into information useful to decisionmakers. This helps to engage the decisionmakers and policymakers who are interested in what is useful to the constituents they represent rather than the technical details. Involvement of the decisionmakers and policymakers from the beginning is important to achieve their approval and long-term support.

GEOSS efforts began in July 2003 in a meeting at Washington, DC and continued with three summit meetings attended by ministers of countries, as well as technical personnel. Participants include 60 member countries and more than 40 organizations. An Executive Committee empowered four co-chairs: two representatives from developed countries (U.S. and European Commission) and two representatives from developing nations (China and South Africa) to steer GEOSS efforts. In the February 2005, the ministers endorsed a 10-year plan. Now efforts will focus on the program, the outcomes, and the parts of the system that will make the objectives of the 10-year plan happen. This will require bilateral and multilateral collaborations to be successful.

The GEOSS efforts frame everything in terms of societal benefits that emphasize the link with governments and ministers—what can integrated earth observations do for things that society needs or cares about? Nine societal benefits of improved earth observation have been identified:

- Natural and human-induced disasters
- Climate variability and change
- Biodiversity
- Weather information, forecasting, and warning
- Human health and well-being
- Water resources
- Terrestrial, coastal, and marine ecosystems
- Sustainable agriculture and desertification
- Energy resources.

During 1990 to 1999, disasters killed over 500,000 people and caused $750 billion in damages. In the U.S. alone, there were four major hurricanes, threats of eruption from Mount St. Helens, heavy rainfall caused landslides in California, and several significant earthquakes. These events emphasize the importance of this societal benefit area. The ministers that met this year asked not about technology, but how to get information into the hands of local persons for warning, education, and protection of lives and property.

In the U.S., there has been increased interest in wildfires over last few years because of heavy fire seasons. Also, people are moving into the wildland interfaces, so forest fires have much greater impact than before. Thus, tracking of fires and their impacts are of great interest in monitoring forest health, forest ecology, forest systems, and post-fire effects.

There is no better example of collaboration and integration than efforts to bring together the ocean, coastal, and terrestrial systems. These systems are interlinked, although they are often treated as separate systems, and each has scientific interest. As an example, the National Oceanic and Atmospheric Administration (NOAA) has a "white water to blue water" program in the Caribbean area that is attempting to integrate watershed, marine, and coastal ecosystems together. This program involves upstream and downstream elements to include cause and effect, and will build capabilities in an ocean observing system to strengthen what goes on in the Caribbean area similar to the efforts underway in the tsunami and earthquake programs. All of this can come together in an integrated approach.

Human health and well being considers how environmental issues impact health issues and environmental management capability. For example, over 300 million people are infected with malaria annually and about 1 million people die each year. The malaria development cycle is intensified in El Nino years, so it may be possible to link atmospheric and ocean observations with the ability to project and predict the effects and impacts of malaria development. Such a comprehensive linkage of physical, chemical, biological, and natural systems into a human health perspective enables us to understand and address malaria, droughts, and other occurrences. Bringing together information on air quality, air mass movements, and meteorological data can enhance our ability to observe these systems *in situ* and from space.

Agriculture and food supply is of broad interest on a global scale. Factors affecting our ability to provide enough food on a global basis include the landscape, soil erosion, soil processes, desertification, drought, soil quality, soil management, and agricultural practices. Weather and climate patterns that affect agriculture on a long-term basis can be integrated to enhance our ability to address agricultural productivity on a global basis. This is of particular interest is Africa where famine is a daily issue.

Combating desertification and drought is an issue for the U.S. and for the world. There is a need to understand what is happening now and the impacts of events such as El Nino and La Nina patterns, which affect food production, food supply, water supply, and wildfires. Drought is costing $6 to 8 billion annually in just the U.S. There is a need for both a domestic plan and an international plan to address drought and to develop a drought warning system.

Energy resource management and production is of great interest right now, including how much resources we have left, how to optimize use of remaining resources, and interest in the environmental aspects of fossil fuel use and alternative fuel utilization. Other areas of interest are development of remaining resources and impacts of this on ocean and land. An example is oil and natural gas production in the Gulf of Mexico that supplies 27 percent of these resources to the U.S. and includes significant investment in infrastructure (e.g., 20,000 miles of pipeline, 4,000 active platforms); these production systems are developing energy resources, are impacting the environment, and are impacted by the environment (e.g., hurricanes). The ability to predict conditions with an adverse impact on these facilities is important, not only to maintaining production and protecting financial investment, but to environmental protection as well. The ability to improve weather forecast information results in about $10 million in value for 24 hours advance warning.

As these examples demonstrate, improvement in any of the nine societal benefit areas has large benefits and provides opportunities for collaboration and cooperation. Note that the terms warning system, projection, prediction, and forecasting show up in every benefit area example. Observations are needed to be able to make predictions and to be able to use models to turn that information into decision support systems. Therefore, prediction, projection, and forecasting are extremely important.

The information technology architecture for GEOSS that provides the observation information is a system that must be interoperable and the information must be transitioned to decisionmakers in ways they can use it (e.g., tools, etc.) in order to achieve societal benefits. Those in the science and technology fields must strive to ask the decisionmakers what they need and, in turn, the decisionmakers must strive to communicate what they need. GEOSS can be a major force to make this happen.

The U.S. contribution to GEOSS is set forth in a strategic 10-year plan for an Integrated Earth Observation System (IEOS). This plan prioritizes and identifies U.S. capabilities, recognizes the importance of common data standards, and is compatible with the international architecture. This plan can be used by others as a model and was developed with strong national support within the U.S. involving more than 16 participating federal agencies and other organizations.

The U.S. strategic plan identifies nine societal benefits that are similar to the international list, but with some subtle differences:

- Loss of life and property
- Protect and monitor ocean resources
- Climate variability and change
- Sustainable agriculture and forestry
- Combat desertification and drought
- Human health and well-being
- Ecological forecasts
- Protect and monitor water resources
- Monitor and manage energy resources.

The strategic plan identifies gaps and needs in all areas and integrates them together. Near-term opportunities include a data management system for earth observations, improved observations for disaster warnings, a global land observing system, a sea level observing system, a national integrated drought information system, and an air quality assessment and forecasting system. These reflect specific U.S. interests and build on existing efforts. One difference between U.S. and international efforts is that the U.S. already has a sophisticated weather monitoring system so efforts under the 10-year plan focus on improvements rather than system development.

In addition, the strategic plans must consider assets, such as satellite-based, aircraft-based, and *in situ* monitoring. While satellite companies promote satellite platforms and space-based data are useful, the EPA, USGS, and others also note the importance of *in situ* monitoring, which is of particular value to developing nations. The December 2004 tsunami in Asia pointed out the importance of *in situ* monitoring (e.g., seismometers, etc.) that could be used to predict impacts.

GEOSS and IEOS are great opportunities for the geospatial community because they will require well designed, well managed, and well implemented information and geospatial systems (nationally and internationally) to bring all the data together. Success with this requires education, technology transfer, and outreach to help the technical community and decisionmakers understand how these systems work and to build the necessary capacity to support decisionmaking on a national and international scale.

Additional information on GEOSS is available at http://earthobservations.org (for international) and at http://iwgeo.ssc.nasa.gov (for the U.S.).

European Research Policy for Environmental Risk and Emergency Management

Mr. William Sonntag, Chief of Staff with OEI, introduced Dr. Karen Fabbri, Scientific Officer for Risk, Management with the European Commission, who discussed European research programs and efforts supporting environmental risk and emergency management.

The European Commission is the largest of the European Union (EU) institutions and its role is to propose and implement EU policies. The European Commission is made up of Directorate Generals, which are comparable to Departments in the U.S; some of the Directorate Generals are for policy and some are for research. The European Commission supports research through a series of framework programs and each covers 4 years; for Framework Program 6, the current program, the budget is 17.5 billion euros.

The goal of the Directorate General for Information, Society, and Media (DGINFSO) is to promote European research in the information and commercial technology (ICT) area, which includes environmental risk and management. Much is coordinated with the EU Environmental Action Program and the EU Sustainable Development Strategy. There is also a Civil Protection Community Action Program and activities that relate to disasters.

DGINFSO promotes international and multidisciplinary research consortia and encourages industrial and end-user involvement through research projects via calls for proposals and support for traditional projects, conferences, workshops, publications, fellowships, etc. There are eight research priorities and the biggest funding priority is for information technologies (29 percent). Other research priorities include genomics and biotechnology for health; sustainable development and change; nanotechnology, materials, and production; aeronautics and space; food safety and health risks; and citizens and governance as well as wider fields of research.

The overall approach is to promote the development of cost-effective sustainable services. Technology integration is solution driven and market/user needs driven. The focus is on interoperability and sound,

state-of-the-art scientific knowledge. A particular emphasis at this time is on the disaster management cycle—from prevention and mitigation to preparedness, alert, response, post-disaster, and reconstruction. Specific emphasis is on the areas of preparedness, alert, and response.

Risk management is not a well organized discipline and there is no clear methodology to handle interrelated risks. Many potential service providers do not understand operational needs and there is unclear organizational responsibility for information generation. In addition, information systems are incompatible and access to relevant data is not easy. Why invest in risk management? There has been a steep increase in natural and industrial disasters for a variety of reasons. Improvements in early warning capability can be helpful, yet there is a lack of interoperability.

Criteria that are considered for investing in research and development are whether the research and development will open up new markets and whether the EU industry will benefit. Therefore, for disaster management, the calls for research projects in the information technology areas focus on technology integration and specialized technology development such as robust/smart sensors; advanced modeling and simulation; high performance computing; decision support and visualization tools; distributed command, control, communications, and computer (C4) systems; integration of earth observation data with *in situ* data; and knowledge management.

There are a number of large, integrated projects ongoing. In the area of risk information infrastructure and generic services, this includes distributed computing, workflow management, collaborative efforts, language issues, ground segment interface, open architecture, thematic applications support, web services, and ontology. In the area of emergency management, this includes command, control, and communication (C3) systems, positioning systems, situational awareness, and emergency telecommunications. Missing elements include risk-specific applications to populate common information and service systems, improved monitoring capabilities, and faster than real-time models. Therefore, future investments will involve broadband telecommunications; high altitude platforms to monitor oil spills, forest fires, flood, and traffic as well as to provide emergency telecommunications; ultra-wideband radio for positioning and communication for emergency situations; smart sensors; and sensor web architecture.

An example is Call 5, which is a recent call for proposals to overcome market fragmentation by developing systems and services relevant to risk and emergency management that are interoperable, open, evolutionary, adaptive, and applicable to cross-border operations; this effort has a budget of 40 million euros. Call 5 focuses on risks leading to emergencies and/or environmental crises such as national hazards or industrial accidents, but involves a more open approach to be able to include areas like air pollution. Another goal is to encourage research to consider dual use (military and civilian) of systems and components.

Call 5 consists of several thematic areas. One area is *in situ* monitoring, which involves the development of systems, services, and smart sensor networks (terrestrial, airborne) for measurement platforms and communications backhaul during crisis operations. A second area involves research on public safety communication and alert systems, including rapidly deployable emergency telecommunication systems, considering the safety needs of personnel in the front line and enhanced international response to major disasters. A third area involves supporting actions to achieve full interoperability by extending ongoing work on risk and emergency management to a broader scope of environmental degradation, developing mechanisms that support early adoption of a common information and service architecture, and supporting convergences in the field of public safety communication.

Call 6 is in development and involves the development, validation, and demonstration of a distributed tsunami early warning and alert system relevant to Europe and the Indian Ocean. The EU has mobilized

for humanitarian aid, but wants to make a scientific contribution in this area. The goals are to enable strong collaboration and interoperability across the whole disaster reduction cycle; integrate advanced data exchange and fusion technologies, real-time forecasting, and advanced detection through grid-enabled computing, collaborative networking, and all media broadcasting; and validate environments for testing prototype integrated systems and services.

An upcoming event is a Global Monitoring for Environment and Security (GMES) architecture workshop in Brussels in June 2005 to address data integration and information management within the GMES action plan as well as validation on risk management applications. There will also be a 2-day conference on civil protection and response at the INTERSCHUTZ World's Fair and at ENVIROINFO to brainstorm on what to do in the future for research in this area.

There are several funding mechanisms and all are open to international cooperation. Third country participation (i.e., outside of the EU's 25 member countries) is a cross-cutting issue and there are programs with specific measures for international cooperation and for international mobility of researchers. There are a series of target countries, such as the U.S., for cooperation agreements. An example is a pilot phase cooperative agreement between the U.S. National Science Foundation (NSF) and DGINFSO. The NSF set aside $1 million for 1 year to promote cooperation between NSF grantees and 11 ongoing EU projects, including embedded systems, e-health, e-government, trust, and security. The second pilot phase, being started this summer, may include environmental projects. There is a bilateral agreement under which project partners decide on tasks to be carried out and on the intellectual property rights.

Another initiative is GMES, which is a joint initiative of the European Commission and the European Space Agency to coordinate and enhance existing earth observation and monitoring capabilities to support improved decisionmaking on issues of environment and security. There is a research-driven stage followed by an operational phase (by 2008). The idea is to make the end-to-end earth observation value chain more effective by delivering data and information to end users, organizing the supply, federating the demand (e.g., user-pull, not technology-pushed), and establishing a sustained dialogue with end users. GMES is an important contribution to GEOSS with contributions via EU regional and national earth observation networks and EU research and development such as disaster management.

A third initiative is INSPIRE—a European Commission initiative on the use of geographic information in Europe as a contribution to environmental policy and sustainable development. The objectives are to make spatial data available for community environmental policy through the establishment of integrated spatial information services, based upon a distributed network of databases linked by common standards and protocols to ensure compatibility. Geographical information should be collected once and maintained at the appropriate levels, seamlessly, and be shared, available, easy to find, easy to access, and presented in an understandable visual form. This includes a theme on natural and human-induced disasters.

A fourth, smaller initiative begun a few years ago is the Euro-Mediterranean Disaster Information Network. This initiative promotes the sharing of disaster-related information, research, results, knowledge, and expertise to improve pre-disaster planning as well as hazard, vulnerability, and risk assessments. This has various disaster themes such as forest fires, storms, floods, earthquakes, volcanoes, landslides, avalanches, and technological issues as well as horizontal issues such as ICT for disaster management and early warning. More information can be found at http://www.eu-medin.org, which identifies members of the disaster science community, provides products, etc.

The ICT for Framework Program 7 is in development. Research, innovation, and competitiveness are top policy priorities as well as continuity with current Framework Program 6 activities. Therefore, planning includes continuation of the current thematic priorities, scaling up coordination actions, scaling up

fellowships, and trying to involve small and medium enterprises in research actions. The budget will be doubled to help form a European Research Council (which will include a Scientific Council) and to promote new research infrastructures, international cooperation, and new management schemes. ICT, at 28.5 percent of the funding, will be the biggest piece of collaborative efforts. The biggest objective is to enable Europe to master and shape the future developments of ICT so that the demands of its society and economy are met. The main thematic areas are ICT technology pillars, integration of technologies, applications research, and ICT meeting societal challenges.

The disaster management activities are expanding to a broader environmental program that is anticipated to include ecological resource management and assessment of human exposure to environmental stress, as well as continuation of disaster and risk management assessment activities. Activities are anticipated to include diverse environmental and risk-based monitoring, environmental and risk management systems, and emergency management, early warning and alert system activities.

Outside experts are welcome to help in the evaluation of project proposals and those interested in being considered for this can register on the web site.

Sustainability through Science: Moving from Assessment to Outcome-Based Collaborative Action

Mr. Tom Voltaggio, Deputy Regional Administrator for EPA Region 3, introduced Mr. John (Randy) Pomponio, Director of the Environmental Assessment and Innovation Division in EPA Region 3, who discussed examples of EPA use of ORD science to achieve environmental outcomes at the regional level.

The world today is measuring and demonstrating outcomes. This makes it necessary to target science collaboratively and efficiently, to use the science to demonstrate environmental outcomes, and to better articulate these outcomes in order to get the funding to continue this job. The overall challenge is to demonstrate and ensure that research results in environmental outcomes, and this requires that systems be developed that can measure those outcomes. In addition, EPA must effectively deliver the ORD research, science, and expertise to the regions for use in program decisions. There is an opportunity for EPA and its ORD offices and regions and programs to demonstrate that the research will yield environmental benefits and there is an opportunity to deliver this science and expertise to the regions and state programs.

When contemplating the use of science to make a difference, this must be put it in a context. First, there are the endpoints about which society cares and this helps to focus the efforts. Next, efforts are applied as to how to describe these endpoints from an environmental and socioeconomic view. Once we know this setting, efforts can focus on determining the stressors (e.g., air deposition, etc.), human activities causing the stress, the tools and activities that can be implemented to change things, and how to measure success. Science is needed at every level to tell us about stressors and to measure success, and this requires collaboration to find science, information, data, and solutions.

Several examples were presented that illustrated the challenge of using science to achieve outcomes, keys to success, and how real science (put together with collaborators) protected wildlife, streams, and health. The first involves the Mid-Atlantic Integrated Assessment (MAIA)—an EPA Region 3 project that can serve as a national template on how to engage science to create assessments, take action, and achieve science-based environmental outcomes. Keys to the success of the MAIA program include the following:

- Regional senior management believes in and is committed to outcomes delivered by science
- The Region commits to strategically invest in personnel and budgets for science and environmental outcomes

- There is a lead who accepts responsibility for the partnerships

- The Region is organized to institutionalize the technology transfer process and the formation of partnerships

- ORD is an active partner.

A second example is the creation of the Regional Science Integration Team (RSIT), which takes science from ORD and other places, works with ORD and other programs to show how their needs can be met, and takes regional programs to those who are doing real things such as buying property, improving a stream, etc. Often, people are too busy with every day work to engage in science development or to use new products and tools. To prevent good reports from ending up unused and to help implement the science, a core science team can focus on bringing relevant findings and expertise to regions and states and make it operational. This requires targeting the science up front for investment, ensuring that there enough personnel to teach others about this, and offering experiences to other EPA Regions to be inspired for similar outcomes.

In looking at success stories, an important finding is that not all EPA offices and not all parts of ORD look at outcomes of science in the same way. There is a continuum of specific projects to develop the kinds of science needed and to work with partners to achieve the desired environmental outcome. An important area to understand is how other EPA Regions fit within this model and how they organized to achieve more ORD partnerships and positive outcomes.

The EPA Region 3 efforts in this area began with a small group that looked at how to convince people that science can produce results. Conceptually, the science was viewed as buds on a tree and the outcomes were the fruit that develops from them. The next step was to array the science "buds" in EPA Region 3 in three ways: "buds" that exist from collaboration (e.g., reports, etc.), a subset "flowers" that were reports used to influence some environmental endpoint, and a further subset of those reports that were the "fruits" of the efforts. The latter might be stream miles cleaned up, acres of property preserved for habitat, public health initiatives that resulted in less human health problems, etc.

There is a need to inspire each other to keep with this and emphasize outcomes. Senior leaders and Congress will continue to test EPA against results and EPA needs to be prepared with this type of information. We need to pick the science, track it forward to environmental outcomes, and report back on those outcomes. This will demonstrate that science does make a difference, especially when we apply it collaboratively. Examples of such applications of ORD science include:

- Use of an ORD-developed stream benthic index of biotic integrity program by the State of Maryland to develop a Unified Watershed Assessment and identify 58 affected watersheds; based on actions taken, it is possible to track completion of restoration activities for George's Creek and many other watersheds.

- EPA Region 3 work with ORD to develop landscape modeling tools and indicators that the State of Maryland used to develop a Land Conservation Policy signed by the Governor in 2003.

- Use of ORD science to lower DDT levels in herring gull eggs at Lake Michigan

- Use of ORD science to reduce mercury levels in fish in the Florida Everglades.

EPA must be prepared to be able to make statements like this and back them up. Thus, the take home message is that effective collaboration is win-win; it is possible to show that science results in successful

outcomes, and more collaboration is needed to explore ways to enhance collaboration to more effectively link research to environmental outcomes.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) how nanomaterials are of interest to the European Commission, particularly in how to integrate them into environmental information, (2) the European approach to decisions on focal areas in the environment and priority setting including workshops and committee meetings with the scientific community, consultations with the Directorate General for Environment and other Directorates, and contact with member countries to obtain agreement on priorities, (3) the need for collaboration with academia, non-governmental organizations, local government, public stakeholders, researchers, and others in the regional model to apply science for environmental outcomes, and (4) how one of the biggest challenges within EPA in working with ORD is the investment in moving the science to an outcome, a "missing link" of applied science, which is being addressed by initiatives such as the EPA Region 3 RSIT.

Closing Remarks

Dr. Puzak concluded the plenary sessions by thanking all of the speakers for taking time out of their schedules to address the *Science Forum*. Dr. Puzak reminded participants of the poster sessions, exhibits, and additional presentations throughout the *Science Forum*.

Section III: GEOSS and Remote Sensing Technology

Monday, May 16, 2005

The purpose of this plenary session on the first day of the meeting was to highlight how advanced remote sensing techniques are used to enhance environmental management, including how remote sensing is used in EPA programs, strategies to make remote sensing products more available to EPA project and program managers, and EPA's contribution to GEOSS. An audience question and answer period followed the presentations.

Wendy Blake-Coleman with OEI, Terrence Slonecker with NERL, and John Lyons with NERL led this session on remote sensing technologies and GEOSS support. Presentations included a perspective on indirect and direct methods of remote sensing to analyze water quality; the use of remote sensing for historical site analysis, emergency response, archives, site manager needs, and visualization; the collaborative BlueSkyRAINS effort to interpret data, make predictions, perform assessments, and provide societal benefits; applications of remote sensing to some current issues and the EPA response to a Congressional request to construct a "one-stop-shop" for remote sensing projects; enterprise efforts to collect and identify a variety of geospatial data generated and utilized across EPA; a policy promoting collaboration for space-based remote sensing and the impacts of this policy on federal agencies; remote sensing initiatives in the Caribbean region as a model of a GEOSS project; international and national efforts in support of GEOSS; and the EPA Geo-Coordinating Committee.

GEOSS and Remote Sensing Technology

Following opening remarks by Wendy Blake-Coleman (with OEI), Terrence Slonecker (with NERL), and John Lyons (with NERL), 10 speakers addressed the use of remote sensing techniques including regional examples, data issues, GEOSS applications, and the integration of these techniques for more informed decisionmaking. An audience question and answer period followed the presentations.

Remote Sensing and Water Quality

David Jennings, with NERL, discussed indirect and direct methods of using remote sensing to analyze watershed data and to determine water quality using a case study in Clarksburg, Maryland as an example of the applications of these techniques. Characterizing watershed condition is an essential aspect of protecting and monitoring water resources. The watershed affects the receiving waters and therefore must be a critical component of both water quality assessment and mitigation efforts. Landscape analysis allows for both description and prediction. Remote sensing measurements of water quality include indirect measures, such as modeling the relationship of landscapes and water, and direct measures from remote sensors.

With an indirect method, remote sensing is based upon watershed characterization, followed by landscape analysis that is used to classify and model the landscape. The 1997 landscape atlas authored by Bruce Jones is the paradigm for landscape analysis. In addition, Megan Mahaffey performed a study on the New York City water supply, which is the best example of remote sensing and water quality. The study used four data sets to classify drinking water data related to water quality points in order to set up recommendations to target watershed management and drinking water standards. In addition, multiple regression studies were performed to look at changes in nitrogen yield. Graphical slides illustrating the biophysical watershed settings, water quality sample sites, recommendations, multiple regression/gradient studies, and landscape metrics.

Direct remote sensing differs from indirect methods, as it is a direct measurement taken from an instrument, as demonstrated through four discrete, graphical examples: (1) hyperspectral images that measured how many milligrams per liter of Chlorophyll-A were present in every single pixel as compared to ground truth measurements, (2) hyperspectral images of the Ohio River showing measured amounts of chlorophyll, turbidity, and phosphorous, (3) thermal image of Lake Superior that is calibrated using buoy measurements, and (4) aerial photographic interpretation to perform wetlands analysis.

A case study in watershed analysis was also presented to demonstrate direct remote sensing using light detection and ranging (LIDAR). LIDAR is an integrated system that utilizes a positional system to precisely determine sensor location and angle and as a ranging system to determine the distance of the environmental object from the sensor. Two questions were asked: (1) can LIDAR accurately map channel morphology at catchment scale in forested environments, and (2) can LIDAR effectively map changes in channel morphology with repeat LIDAR collects (precision)? If yes, can channel change be associated with changes in landscape and stream flow? A series of images depicting LIDAR function and the use of LIDAR to analyze land development, overland flow, changes in runoff patterns, and cross-section data to address these questions as well as effects of best management practices to improve poor water quality resulting from land development.

Remote Sensing, Visualization, and Scientific Outreach

Carolyn Offutt, with the Office of Solid Waste and Emergency Response (OSWER), discussed historical site analysis, emergency response, EPA remote sensing archives, site manager needs, and visualization. One purpose of remote sensing is to look at historical use by tracing activities and changes through time. An example was shown of the Hooker Superfund Site in 1958 and 1964. Differences between the two

photographs, such as new construction, are evident. Some use remote sensing for emergency response, as it documents the extent of the problem, success of containment, success of clean-up, and environmental recovery. As an example, a photograph was shown of particulates discharging into the ocean following a 2004 forest fire in California.

The EPA remote sensing archives are maintained in Las Vegas, Nevada. There are approximately 4,250 analysis reports, 75,000 cut frames of film, 5,500 rolls of film, 3,700 digital frames on CD and DVD, 500 soil surveys, Landsat (Thematic Mapper) scenes, digital orthographic quadrangles, photographs, hard copy maps, books, indices, and metadata records. OSWER and the Environmental Photographic Interpretation Center (EPIC) are working cooperatively to preserve remote sensing documents and make them available for research and analysis.

Superfund site managers have several needs early in the cleanup process—they must develop an understanding of the site, degree of contamination, and the location. Several options are available such as the use of topographic maps and aerial photographs. Trained interpreters and geographic information system (GIS) analysts use tools for further assistance to describe site contamination. Images in the State of Connecticut demonstrated the use of the Enviromapper software as an example of remote sensing/GIS analysis. Other analysis is performed at EPIC, such as looking at series of photographs to show changes in landscape and building features over time. GIS also helps to overlay wells, develop contour hot spots, demonstrate to the public why sampling is occurring, etc.

Visualization is another method of analysis that takes information from two dimensions to three dimensions. An example would be confining layers of ground and aquifers that may have high contamination. Samples would be taken at the site; however, it would be extremely helpful to have a 3-dimensional tool to help measure the amount of contaminated ground as a result of the measurements. The type of tools people use has increasing analytical complexity. Remote sensing tools, such as those described, are extremely important for OSWER and Superfund Site work.

Air Quality Observations—BlueSkyRAINS

Dorsey Worthy, with NERL, discussed how remote sensing has helped to perform air quality assessments through BlueSkyRAINS, which is a collaborative effort between the National Aeronautics and Space Administration (NASA), United States Department of Agriculture (USDA), EPA, and NOAA.

Strong wildfires can insert fine particulate matter (PM) into the atmosphere where the middle level winds can transport the PM extremely far from its source. Satellite and meteorological data can be combined to help us understand where and if the particles will impact air quality at the ground level. In order to help predict and track smoke plumes, EPA Region 10 developed a GIS to combine the U.S. Forest Service BlueSkyRAINS output with air quality observations. Air quality can be significantly impacted from fire events occurring hundreds or thousands of kilometers away as demonstrated with a series of slides depicting fire locations and subsequent air quality impacts in other areas.

Research activities planned for the summer of 2005 include daily acquisition and evaluation of Terra and Aqua MODIS imagery, Air Quality Index (AQI), and BlueSkyRAINS information; acquisition or production of aerosol optical depth products from Moderate Resolution Imaging Spectroradiometer (MODIS); and geo-location of surface air quality data and reported fire locations on reference maps. AIRNow/AQI, BlueSkyRAINS, aerosol optical depth, and other data products will be combined for comparison.

The spectrum of users ranges from observations to societal benefits. Earth observations, earth system models, scientists, and modelers provide data-to-information archiving and services. This results in

decisionmaking tools for environmental managers and an overall impact on public officials, advocacy groups, and the public. Indicators and forecast features can be determined from data outputs, which will aid in building capacity for local needs and issues. BlueSkyRAINS intends to take earth observations and put them into models and support systems in order for managers and decisionmakers to make more informed decisions.

A figure was shown illustrating the architecture of BlueSkyRAINS and how data from earth observation systems and models are used to model predictions that in turn result in assessments and decision support. The outputs are societal benefits in terms of policy and management decisions. Ongoing feedback from societal users will continue to drive the types and degree of assessments performed.

Collaborative Approaches Using Remote Sensing

Barry Feldman, with EPA Region 6, presented some current problems that remote sensing can address and the EPA response to a Congressional request to construct a "one-stop-shop" for remote sensing projects. Facility inspection responsibilities, environmental monitoring needs, and costs have risen dramatically in recent years, while resources have decreased. This prompts agencies to investigate alternative processes to fulfill their responsibilities. For example, the use of remote sensing will enable environmental agencies and local government officials to identify emissions that may not be part of the current emission inventory or to identify unknown leaks from facility equipment. In the past, multispectral or other remote sensing capabilities were limited to wide-area analyses using low-resolution data—a process ill-suited to the complex urban environment; recent advances in hyperspectral collection yield more detailed information at higher resolutions, offering the capability to detect illegal or unauthorized chemical releases or disposal on land, air, and water.

In 2003, Congress mandated that EPA "*develop a 'one-stop-shop' office to coordinate similar programs which foster private and public sector development of new, cost-effective environmental technologies*." In response to this requirement, EPA committed to establish a "one- stop-shop" web site to link the Agency's technology programs and to establish an environmental technology council. Several programs and projects were proposed and included recovering waste for energy sustainability and monitoring gasification, urban runoff, improved pesticide application, etc; however, remote sensing of pollutants was the number one project recommended.

Over 30 people became part of a remote sensing work group, and there was wide interest from EPA Region 6. Some challenges were encountered such as pervasive applicability (i.e., relatively few people can apply it), cooperation and collaboration for adequate funding and technical resources, and the encouraged growth of remote sensing technologies in terms of resources, tools, and data. EPA Region 6 wanted a different way to look at emissions and to be able to test, identify, and characterize gaseous chemical compounds. EPA Region 6 personnel involved in the work group thought that hyperspectral imaging would provide the big picture and, therefore, reliance on point source monitoring would be reduced.

Several demonstration projects were executed: PlumeEx looked at air quality problems in the Houston area, Houston Ship Channel looked at anomalies in the ship channel, Smart LDAR worked with the petroleum chemical industry to develop better leak detection methods, Cajun Cloud used thermal imaging to detect industrial emissions in Baton Rouge, and a regional haze project used satellite information to study the affects of agricultural burning in Mexico. Slides were shown depicting hyperspectral imagery, technologies, data, and results from the PlumeEx project, in addition to some examples from the Houston Ship Channel project.

EPA Geospatial Data Framework

Brenda Smith, with OEI, provided an overview of the enterprise efforts to collect and identify the variety of geospatial data generated and utilized across EPA as well as policy efforts to streamline the process and methods for storing and retrieving the data. A wide variety of tools and applications exist throughout EPA and this effort attempts to look across the Agency to accomplish these activities on a more enterprise-wide scale. Technology and information needs to be examined from a technological and application perspective to determine if the data and tools can become more accessible. Tool outputs and information quality are based upon the data, and questions cannot be answered without good data; so, it is necessary to better manage and share existing data. Some data management efforts are already underway within ORD, such as the remote sensing gateway, landscape characterization data holdings, and virtual remote sensing information center.

A National Geospatial Data Policy has been in place since 1992 that addresses the management and use of geospatial data. Currently, efforts are underway to implement a plan/policy for the planning, collection/acquisition, processing, storage, access, maintenance, and retirement of data. This amendment to the policy was recently approved by the Quality and Information Council and should become official next month.

Enterprise-level acquisition efforts are currently being explored in order to streamline the data acquisition process and to apply the process throughout EPA. Enterprise license agreements for data and tools, in addition to commercial/web services solutions, would be available and, as a result, data would become more readily available throughout the community. Additional efforts involve the data acquisition architecture. EPA is using enterprise architecture as a way to manage information technology investments and has implemented architecture for a geospatial blueprint update, solutions, and transition planning. At the federal level, a unique profile addresses security and information technology efforts, and a newer profile will serve electronic records. In addition, the Office of Management and Budget (OMB) will be developing a geospatial profile for the 2005 to 2006 Strategic Plan.

Many people utilize geospatial data at EPA. Data inherently is accompanied by metadata, which plays an extremely important role. For example, documenting data sets for quality allows for easier data set searches. A geospatial metadata work group is developing a business process for metadata because it has been challenging to get everyone to document metadata. To assist with this, a web-based tool has been developed and a metadata catalog, the Environmental Information Management System (EIMS), has been initiated to capture EPA metadata with the intention to build off the Environmental Systems Research Institute toolkit. Finally, efforts are being made to make the data more easily accessible using the Integrated Geospatial Database, which serves as a centralized data management center and provides geoprocessing services.

Commercial Remote Sensing Space Policy and Opportunities for Collaboration

Tom Cecere, with the USGS, introduced the Commercial Remote Sensing Space Policy (CRSSP), agency roles, desired outcomes, and potential benefits. The CRSSP was signed by President Bush on April 25, 2003 with the goal to advance and protect U.S. national security and foreign policy interests by maintaining the nation's leadership in remote sensing space activities and sustaining and enhancing the U.S. remote sensing industry. The policy includes the following: (1) rely to the maximum practical extent on U.S. commercial remote sensing space capabilities, (2) focus government systems on needs that cannot be practically met commercially, (3) develop a long-term sustainable relationship with industry, and (4) enable the U.S. commercial remote sensing industry to compete as a provider of remote sensing capabilities to foreign governments and foreign commercial users.

EPA and other civil agencies have collaborated to determine the best way to implement this policy. A CRSSP Shared Execution Team was developed to enable these agencies to leverage assets already available such as contract mechanisms and to promote data sharing and exchange. The National Geospatial-Intelligence Agency (NGA) and the USGS are responsible for infrastructure and architecture. In terms of establishing contracts, NGA and USGS will coordinate procurement mechanisms and ensure broad distribution options for civil needs. NGA and civil purchases will be leveraged in areas of common interest and licenses will be upgraded when additional needs can be met. Several agencies are involved in this effort including the Departments of Agriculture, Commerce, Defense, Energy, Interior, Homeland Security, and Transportation; the Federal Geographic Data Committee; NOAA; the National Capital Planning Commission; and EPA.

The CRSSP Shared Execution Team wants to capture civil agency land-based remote sensing requirements, such as spatial/geospatial, spectral, temporal, and mission. The agencies must inform the Shared Execution Team of their needs and requirements will be fulfilled through partnerships, archived resources, and access to contracted resources. In addition, all agencies must be aware of the activities based upon the requirements. A tool is being developed to capture contact information, observable description, program/project mission, plans to obtain the data, etc. For example, the Great Lakes are a common area for data requirements, the USDA goes out every year and creates 2-meter imagery, and the Border Patrol has the USGS developing high resolution imagery.

Potential benefits include awareness of planned remote sensing purchases and requirements, identified partnerships, awareness of civil remote sensing community points of contact, future system developments, and value-added services. The USGS maintains the CRSSP database and slides were shown depicting login and data queries. This can be accessed at http://cidr.cr.usgs.gov.

The Caribbean Research Initiative: Monitoring the Health and Sustainability of Tropical Island Ecosystems

Terrence Slonecker, with NERL, discussed an EPA initiative to look at the Caribbean area as a model of what a GEOSS project might demonstrate in terms of societal benefits that could actually change people's lives for the better. The Caribbean area was chosen for several reasons. First, concerns were raised by a recent United Nations report on climate change that indicated that the island nations of the South Pacific and the Caribbean will be among the first areas impacted by global climate change. Second, the Southeastern U.S. and the countries of the Caribbean Basin have strong economic links in terms of tourism, fisheries, and manufacturing. Third, GEOSS societal benefit themes are consistent with the project and include natural disaster mitigation, improved weather forecasting, protection of coastal/ocean resources, mitigation of global climate change, human and ecological health, support of sustainable agriculture, protection of water resources, biodiversity/ecological forecasting, and monitoring and managing energy resources.

U.S. territories within the Caribbean Basin include Puerto Rico and the Virgin Islands. The EPA has regulatory responsibility there and the areas are susceptible to natural disasters. A loss of biodiversity has also occurred in terms of the coral reefs, mangrove wetlands, endangered species, and invasive species. In addition, air quality issues are present as a result of PM from Africa that has settled due to orthographic lifting.

The next steps in the Caribbean Initiative include the following: (1) develop a partnership network to conduct surveys and hold workshops with clients, the public, and mangers; (2) identify models, indicators, data, networks, and capabilities needed, in addition to identifying key gaps in science, data, network integration, and institutional relationship; (3) initiate several small, high-visibility pilot projects in Puerto Rico and the Virgin Islands to develop methods for aquatic bio-assessments, land cover change,

population growth models, and passive air quality; and (4) develop a formal research plan and secure appropriate funding.

Integrating Monitoring and Decision Tools for Sustainability

Gary Foley, Director of NERL, provided an overview of GEOSS, its benefits, and associated international and national efforts including plans, partnerships, and requirements. GEOSS includes comprehensive, coordinated, and sustained observations of our planet as a system in order to improve monitoring of the state of the planet, increase understanding of planetary processes, and enhance prediction of the behavior of the Earth system. In addition, GEOSS will provide timely, quality, long-term global information as a basis for sound decisionmaking, and enhanced delivery of benefits to society. GEOSS is a step toward addressing the challenges articulated by the United Nations Millennium Declaration and the 2002 World Summit on Sustainable Development, including the achievement of the Millennium Development Goals**.**

Several countries and international organizations participated in three summits to kick-off GEOSS and to develop and approve a 10-year plan. This effort has moved faster than any other international activity. The 10-year plan contains 2-year, 6-year, and 10-year outcomes. Understanding the Earth system is crucial to enhancing human health, safety, and welfare; alleviating human suffering including poverty; protecting the global environment; reducing disaster losses; and achieving sustainable development.

The 10-year plan is a reference and is not a negotiated text. The purpose of the 10-year plan is to provide details to complement the *10 Year Implementation Plan* and form the basis for actions in 2005 and in subsequent work plans. The U.S. has also released a strategic plan for the IEOS in which a global system of earth observations would provide the tools and capacity to make national and global air quality forecasts, to know in advance when droughts would occur and how long they would last, and to predict the outbreak of deadly diseases by tracking the environmental factors that contribute to their spread.

GEOSS connects to sustainability because it helps to interconnect decisions, and this is the entire message of GEOSS. The architecture is set up to include earth observation systems and earth systems models with all of the information feeding into information support. This is all aimed at producing the societal benefits outlined in the plenary session and feedback. Nine societal benefits were identified: improve weather forecasting; reduce loss of life and property from disasters; protect and monitor our ocean resources; understand, assess, predict, mitigate, and adapt to climate variability and change; support sustainable agriculture and forestry and combat land degradation; understand the effects of environmental factors on human health and well-being; develop the capacity to make ecological forecasts; protect and monitor water resources; and monitor and manage energy resources.

The 10-year plan also lays out an approach that moves from the bottom up by starting with a user face/community. People at EPA and other agencies that make observations are at the heart of GEOSS and those observations must be tied into user/societal benefits. A wide spectrum of users exist, such as scientists, modelers, environmental managers, and public officials, and all of the groups speak a different language with varying needs. If the users can all speak the same language, then the information can be delivered and tailored to the use of the community. The focus is on decision support tools and getting people to own them, getting users to talk about them, and creating the best way for the information to be used.

EPA GEO-Coordinating Committee: Why EPA and Near-Term Opportunities for EPA

Steve Young, with OEI, presented an overall view of the EPA role in GEOSS, and Ed Washburn, with ORD, discussed the efforts specific to EPA. EPA is working with numerous federal agencies to support

GEOSS, which involves over 50 countries. EPA is recognized as a focal point for environmental leadership and has collaborated with many other agencies. EPA has the understanding that better information about the environment is critical for better decisionmaking. Over the last 7 years, EPA has improved environmental indicators to track the condition of the environment and has been committed to demonstrating outcomes of the programs. The current opportunities under GEOSS align with EPA, as a better understanding of the system can lead to better decisionmaking. GEOSS will help to understand the Earth system, including point source pollution, climate, and sustainable issues, and will help to provide better information about the condition of the environment.

Up until a few months ago, EPA was coordinating GEOSS activities through an *ad hoc* effort but realized the need for something more formal. As a result, EPA will coordinate with GEOSS by establishing an EPA GEOSS Coordinating Committee with co-chairs from ORD and OEI. EPA will identify database systems, decision support tools, integration needs, and end user needs. EPA also will collaboratively develop ORD's FY06 Advanced Monitoring Initiative (AMI), which will provide a knowledgebase of improved environmental health decisionmaking. Test pilots will begin with small-scale projects, but processes and data can be transferred to larger-scale projects.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) the current limitations in being able to look at watershed impacts from development on a prospective basis rather than retrospective basis; (2) aerosol optical depth being a derived spectral product rather than a direct ozone measurement in the BlueSkyRAINS project; (3) whether BlueSkyRAINS will look at forest fire components other than aerosols and plans to add LIDAR to field and thermal spectral thermometers in the summer of 2005; (4) partnerships with scientists at Caribbean universities to support the Caribbean Region Initiative; (5) the need to collaborate between the Caribbean Research Initiative and NOAA work; (6) consideration of volcanic vulnerability in the Caribbean Research Initiative; (7) effective communication strategies for GEOSS, such as demonstrating pilot study results to decisionmakers; (8) interest in augmenting existing AMI projects and openness to projects with different scales, (9) a request for examples of the use of remote sensing for bacteria and algal blooms and examples of NASA work on prediction of algal bloom, NOAA work to determine how to dissect color that can characterize blooms, a NOAA coast watch program with daily coastal algal bloom products, NASA efforts to identify species-specific chlorophyll types to use to identify harmful phytoplankton, and NSF activities examining the use of satellite data to predict outgrowth off coastal areas of phytoplankton, which is a carrier for cholera; (12) how budget issues will affect the number of small projects to be conducted in support of AMI and examples of multi-agency funding and in-kind contributions to support air quality projects; (13) the need to engage more participants across EPA in GEOSS support activities; (14) concerns about the need to engage participants from outside the remote sensing community to support GEOSS activities; (15) the possibility of academic and private partnerships to support GEOSS through participation in pilot projects and provision of in-kind resources as well as the need to better communicate GEOSS activities to a broader community; (16) the ability of users to use sophisticated GIS tools, such as visualization, and challenges to overcome including how user access and use decline with increases in tool complexity; and (17) questions on how to consolidate data collection and tool development across EPA including the need to identify the data needs, how to address them, and in what priority as well as the need for an execution team to put it all together and tap into all of the data and resources.

Section IV: Office of Environmental Information Track

Tuesday and Wednesday, May 17-18, 2005

The purpose of this breakout session on the second and third days of the meeting was to focus on the management of scientific data for effective interactive analysis and decisionmaking, the use of scientific data and environmental information in decisionmaking, collaboration and comparability in national water quality monitoring programs, use of exchange networks and data standards to improve and encourage the exchange of data, development and application of environmental indicators, language and metadata management initiatives, and information system architecture and tools to support scientific collaboration and decisionmaking. Each session included opportunities to respond to audience questions that provided additional information and insight on a variety of science, information technology, and environmental topics.

Robin Gonzalez, with the National Computer Center in Office of Technology Operations and Planning, led a session addressing advanced computing tools and techniques for managing and understanding large volumes of data. Presentations included applications of grid computing to the life sciences, the use of advanced text analytics to manage and analyze large quantities of information in text form, the acquisition of high throughput data and its analysis with algorithms to develop predictive models in the life sciences, and challenges in visualization and interactive simulation of multiple data sets.

Matthew Clark, with the National Center for Environmental Research (NCER), led a session addressing the use of environmental information to make decisions, reduce releases, and change behavior. Presentations included examination of the linkages between science, behavior, and how people view/use information, the use of Toxics Release Inventory (TRI) data by various organizations to reduce releases, how changes in reporting thresholds affect decisionmaking based on TRI data, achievement of health benefits through improved beach monitoring techniques, the effect of green labels on consumer behavior, and how the ozone alert system is used to make behavior changes on a day-to-day basis to reduce exposure.

Chuck Spooner, with the Office of Wetlands, Oceans, and Watersheds (OWOW), led a session addressing diverse national water quality monitoring initiatives and the collaboration and challenges involved in these activities. Presentations included an overview of the efforts to develop a National Water Quality Monitoring Network, identification of water quality data elements and their documentation to better manage the data and facilitate data exchanges, an overview of the Wadeable Stream Assessment and associated data comparability studies, and use of the National Environmental Methods Index (NEMI) to select and compare analytical methods.

Andrew Battin, with OEI, led a session addressing exchange networks and data standards to facilitate data sharing. Presentations included an overview of the EPA Exchange Network to provide data flow between states and EPA, the development and implications for adoption of the Environmental Sampling, Analysis,

and Results (ESAR) data standard, an overview of the Pacific Northwest Water Quality Data Exchange supporting state-to-state sharing of water quality and other information, and an overview of environmental information exchange systems developed by the Washington Department of Ecology for sharing information on an intrastate and interstate basis.

Heather Case, with OEI, led a session addressing the complexity, applications, and challenges of environmental indicators. Presentations included definitions of indicators and indices including issues of scale and use in decisionmaking, the history and evolution of the AQI, the use of air quality information to elicit action at the local level to protect health and reduce air pollution, and the challenges of scale in interpreting indicators and using indicators in decisionmaking.

Larry Fitzwater, with the OEI Office of Information Collection (OIC), led a session addressing metadata, environmental terminology, and standards applicable to efforts in these areas. Presentations included an overview of metadata, concept management, content management, the semantic web, and International Standardization Organization (ISO) Standard 11179 underlying activities in these areas; the international ecoinformatics initiative and the challenges associated with developing a common terminology to use for environmental data and to address metadata; and European efforts to develop an environmental data exchange.

Megan Quinn, with OEI, led a session addressing the overall architecture and various information technology systems being developed at EPA to facilitate the exchange and analysis of scientific and other data. Presentations included an overview of the EPA Enterprise Architecture and the EPA research and science architecture to provide the necessary infrastructure, applications, and tools to facilitate data sharing and use; an overview of the EPA Science Portal that is being developed to support ORD and the EPA Regions with scientific data and models; an overview of the Window to Regional Applications (WRApp) that is being developed to provide access at the regional and state level to tools, data, and decision support systems with an emphasis on water; and an overview of guidance and a model selection tool to develop a knowledge base of all models used at EPA and to assist users in selecting models appropriate to their need.

Managing Scientific Data for Effective Interactive Analysis and Decisionmaking

Following opening remarks by Robin Gonzalez with the EPA National Computer Center, four speakers addressed the use of information technology to manage and analyze scientific data, the use of grid computing in life science applications, the use of advanced text analytics to analyze scientific data, and challenges associated with visualization and assimilation of multiple data sets. An audience question and answer period followed the presentations.

Managing and Analyzing Scientific Data with Information Technology Tools

Robin Gonzalez, Director of the National Computer Center in Office of Technology Operations and Planning, discussed efforts underway to build the capabilities to support activities within EPA and to address some of the issues faced by scientists and researchers. The EPA mission is to protect human health and the environment and to do this, the National Computer Center supports over 400 applications (scientific, administrative, and programmatic) and databases; provides secure internet and intranet access (internally and externally) through a high speed, high visibility network; and supports researchers with high performance grid computing, grid technologies, advanced visualization tools, and other techniques.

EPA is working on many issues and involves many collaborative partners in those efforts. One quest is to better understand the triggers that affect genetic susceptibility. This involves human and ecosystem health data coupled with atmospheric modeling, land characterization, and water characterization; integrating that data with some of the microscopic areas (e.g., protonomics, genomics, metabonomics, computational toxicology); then integrating all of that with the medical GIS perspective. If there are atmospheric events that can create certain health effects, do we know exactly what the health data are showing? Do we have some data from the medical GIS like the National Institutes of Health (NIH) will be using with the National Children's Study? How do we integrate this information? Some of these questions and issues are critical to building a platform for the science to move ahead.

Some of the solutions to building this platform include data, compute, and storage grids as well as discovery, analysis, and visualization tools. The data grid is starting up and there is success in showing how to do modeling across a network such as modeling efforts between the State of New York and EPA in Research Triangle Park. There are also a number of discovery, analysis, and visualization tools that will be discussed in this session.

The overall goal is to be able to better predict and project the effects for better decisionmaking. A graphic illustrated the current state of affairs, including major initiatives and enabling technologies that sustain those initiatives as well as the challenges, of which some are significant.

Grids are Real: Grids in the Life Sciences

Andrew Grimshaw, Professor of Computer Science with the University of Virginia, discussed grid computing, applications to the life sciences, and the Global Bio-Grid. Today's computing involves numerous and large data sets that change on different frequencies/schedules and are accessed by multiple users at different locations and involve organizations with various access/control policies to be enforced, resulting in increased computational load and spikes in demand for computing power. Some of the data and visualization requirements can have complex staging requirements, so there are pipelined/variable workflows rather than single application runs. There are also competing desires to access and share resources while maintaining access control without providing accounts to every user on every system.

The end users of the data want consistent access and ability to share data easily and without multiple passwords. There also is a need to support legacy applications on new platforms without revising the

underlying code. From the information technology support perspective, there is the need to protect the intellectual property of the organization, protect the computer assets, and balance those needs with the system role to support the conduct of science. These various end user needs can be conflicting.

Grids are a collection of distributed systems connected by a network. From the end user perspective, a grid is about gathering resources and making them accessible to users and applications across multiple administrative domains for collaboration, faster execution, and other goals. Grid computing also can mean several different things, such as high throughput computing or desktop cycle aggregation; cluster grids in a single administrative domain; campus/enterprise grids involving multiple administrative domains, multiple file systems, and wide area network connections (with associated bandwidth and connectivity issues); and partner grids, which is where we are trying to go – the technology is there but achieving this sociologically is difficult because of the level of trust required.

The Legion Grid is an example of how to globally map together computer resources in different organizations controlled by a variety of systems for access in a transparent manner. The user can authenticate to the system once at the desktop computer, then access everything needed through a single portal while the underlying system finds data, applications, and computational resources; makes scheduling decisions; and addresses restart issues associated with a networked computer resource being unavailable. The idea is to hook together databases once, have the underlying system manage the details, and for users to be able to run their existing applications without modifying them for the system. This is important for the scientific users because everything they developed to work in a UNIX/LINUX environment will work in the new environment and the code does not have to be changed.

A computing grid, such as the Legion Grid, brings together heterogeneous computational resources. There used to be nine operating systems that had to be supported to be effective; now there are just two – LINUX and Windows. The key aspect is that the user has to run only one application and the system does the rest; the user no longer has to think about the computing details. The goal is to be able to hook together all grid computing elements so they work together, there can be single updates of databases (so each user does not have to update), and the data can be shared among collaborative research teams. The information technology personnel then keep this working for the end users.

The Global Grid Forum is the standards organization for this. Open Grid Services Architecture (OGSA) is the architecture standard and addresses all major aspects of grid computing: security, data, execution, provisioning, management, and availability among others. OGSA has component standards for execution, naming, files, databases, and resource discovery underway.

Life sciences are a particularly strong area for global application of grid computing. An example of the Global Bio-Grid concept is the use of Legion DG technology to link the University of Virginia, the North Carolina Biosciences Organization, University of Texas, Texas Tech, and others. This system uses the Legion 1.8 computing grid and involves four different clusters with different queuing systems and a collection of Windows XP desktop computers. These efforts have found that it is easier to share data than computing resources.

One application of this system is to look for biomarkers for prostate cancer by examining mass spectrometer biomarker data and all patient data to determine why some patients live if given chemotherapy and why others die no matter what treatment is provided after the cancer has metastasized. Another application involves increasing the ability to query the PubMed database online within the 100 query daily limit by building a data grid “shim” so queries are performed against cached data rather than the original database itself; this also involves distribution of query origination so that they do not count against the 100 maximum queries allowed in a day. These researchers are also involved in cardiology and radiology projects because so little data are integrated in these areas in the hospital environment.

Using Advanced Text Analytics to Manage and Analyze Scientific Data

Larry Proctor, with the International Business Machine Corporation (IBM)-Almaden Research Center, discussed advanced text analytics, applications of this technique to analyzing large quantities of data in text form, and a collaborative research project in this area between IBM and EPA. Digital content is growing at an unprecedented pace, and large quantities of text are becoming available to the end consumer. Data are becoming more heterogeneous and there are multiple data structures. About 85% of knowledge is in unstructured text. Text used to be a document, but now includes photographs, java scripts, voice, and other forms. With Internet growth, the information environment is vast and rich in content and sources. Because of this, it is becoming more difficult to gain insights and derive actionable things from the information.

Finding, organizing, and analyzing information into a useful form is a difficult and time consuming task. Today, there are few good ways to analyze a document other than to "search and read text." Advanced data and text mining tools enable users to perform complex searches of heterogeneous content and to develop insights by identifying patterns and trends from the data. Many of the things we look for we do not know how to find because we cannot put it in words—it may be a concept, theory, or idea.

Structured data provides information in an understandable context. For example, "name" is in a field called "Last Name." Once the data are in those fields, data mining can extract/use the data. A lot of money is spent to put data into structured form.

Over 85% of our data is not in this form, so how do we do this? One method is to look at unstructured information and derive the information of interest from the context. For example, an algorithm for name spotting can be used to pull out names from text; the algorithm determines that the word is a proper noun and represents a person's name. The algorithm can be trained to recognize that terms such as "CEO" apply to names. Similarly, it is possible to find numbers, zip codes, etc. that have a format/structure. This method gets to about 35 to 40 percent of knowledge. Another technique is to build a training set to learn that a proper name is a city or to start combining things in semantic context to determine associations (e.g., words that describe age or position). While this technique is very powerful, a major problem is that it quickly decreases in effectiveness when dealing with a large number of documents because of time for processing. Another approach is to use text found in documents to find insights. This involves clustering or classification to group words. There are a number of techniques to accomplish this including training sets, natural classifications, statistical methods, and semantic methods. Not all of these will complete classifications on their own and may require human interaction to resolve uncertainties.

One way to analyze the content in a set of documents is to read, but that takes a long time. Advanced text analytics techniques can look at concepts such as money, illness, death, disease, smoking, etc. to analyze health data and to look for terms associated with disease, such as people, a company name, chemical structures, patents, etc. Using this technique, it is also possible to look at nonobvious things such as people associated with diseases.

Advanced text analytics moves beyond search capability to find information and assist with information analysis, significantly reduces the time required to assemble and analyze information, enables discovery of relationships not previously known (e.g., technology trends for next 10 years, who are leaders), and can find nonobvious relationships. While "search" is a general tool, advanced text analytics is targeted to people whose job is to analyze information.

IBM has collaborated with EPA in an application of advanced text analytics to find associations with toxic effects using information in the EPA high production volume chemicals documents. One question

was how to take chemicals extracted from this information repository and review patent data to see how these chemicals might be used in processes. The biggest challenge encountered was in getting to the data because the documents were all images; it was necessary to put the documents in a form/format that could be read.

Effective Analysis of Biological Data

Grant Heffelfinger, Deputy Director of Molecular and Computational Biosciences at the Biological and Energy Science Center at Sandia National Laboratories, discussed high throughput experimental data, the need for algorithms to digest the data, and the kinds of high fidelity measurements needed to develop predictive models with applications to the life sciences. The biosciences revolution began with the gene sequencing revolution. However, we want to be able to combine those biological data with predictive models at the cellular or ecosystem level and with other data that is not high throughput, such as image/climate data and data from ecogenomic sensors, and connect that with what is known via text mining and data from the Internet.

Effective analysis of scientific data requires that the data must be quantifiably reliable. To develop experimental data, data analysis is necessary to refine the information. To do this effectively requires an iterative process of data analysis and experiments resulting in high throughput experimental data that is annotated and linked to larger-scale models to be predictive.

An example is the development of hyperspectral imaging and its use for gene expression analysis. This system collects an entire spectrum at each pixel in a 2-dimensional array. Commercial scanners just collect photons whereas this system collects the entire spectrum. Algorithms are used to make measurements and to resolve overlapping spectra. For example, researchers found a contaminant in the buffer solution that overlaps the Cy3 dye; Cy3 and Cy5 dyes are used to indicate whether a gene is turned on or off. Researchers used algorithms to discriminate the contaminant from the Cy3 dye, reduce the data volume, analyze the amount of error, and reduce computation time. This illustrates how algorithms can help with data processing.

A series of slides showed the whole genome of the *Synechococcus* array and hyperspectral imaging results demonstrating how this process produced reliable experimental results through use of statistically relevant experimental design. The hyperspectral scanning approach allowed use of additional dyes even if they had overlapping spectra, which can be resolved using algorithms.

The overall goal is to combine this type of high throughput data with high fidelity measurements to develop predictive models. Slides demonstrated application of the same algorithms in combination with 3-dimensional hyperspectral imaging to see whole, live cells involved in carbon fixing. This enabled researchers to see the distribution of pigments within each cell and across the population; this showed how individual cells were in different stages of the cell cycle. These results were achieved by taking a full spectrum in three dimensions and using algorithms to color pigments, see overlapping spectra, remove overlap, and spatially place the cells.

This technique is useful to measure rate constants to simulate a cell for predictive modeling. The spectra distributed over a cell can be followed through time in order to elucidate reaction rate constants to use in a predictive model. This demonstrates how high throughput, high resolution measurements can be coupled to predictive models.

Developing cell simulation tools is an area of interest in predictive modeling. "*The era of the 'well mixed' cell is behind us…. Many important questions in cell signaling … need to be considered as [at*

least] four-dimensional processes that take place in a complex inhomogeneous geometry." (Olaf Andersen, J General Physiology, 125, Dec. 2004, p. 3-12.)

An example of cell simulation using hyperspectral scanning showed cell imaging, spatial placement, and rotation to see the cells in three dimensions. Again, algorithms enabled researchers to elucidate the fullness of the data. Another example involved collaboration with NERL on metabonomics to use multivariate curve resolution of microscopy data for test animals exposed to conazole fungicides and analysis for metabolites. A third example involved collaboration with EPA using multivariate analysis of satellite spectral data on Chlorophyll-A to monitor river water quality (in the Ohio River) over wide spatial regions.

Interactive Multi-Data Set Visualization and Assimilation Challenges

Todd Plessel, with Lockheed Martin, discussed the efforts and challenges associated with visualization and assimilation of multi-data sets. A multi-data set refers to data that come from different sources; visualization involves the application of graphics to gain insights and see what might not be seen; and assimilation involves the incorporation of data for computation, such as in a cross-media model.

One example of processing multiple data sets is the Regional Acid Deposition Model, which brings in GIS data, surface site observation data (with data of different units corrected to have the same meaning for ozone quantity in all data sets), and land use data (with addition of projection into Lambert space and provision of multiple resolutions of source data). Other data sets added include area-based data such as Federal Implementation Plans for county emissions, watershed data in hydrologic unit code, and air quality data from aircraft measurements (illustrating difficulties in matching information from different sources). By adding plumes, smoke stack data, and wind data, it is possible to estimate the path of a particle released from a specific smokestack. This is a turn-key application example. While it appears that all types of data can be brought in with little problem, in actuality a great deal of effort was necessary to gather the data sets and process them into a form accessible on demand. The result is a fixed set of data that are available in Models3-type files. This is not very end user customizable.

More common is the single use, "throw-away" application. This is done for short-term projects, has limited hard coded capabilities, and involves a lower, but not trivial, effort to develop. An example is a one-shot visualization demonstration in the Yukon region, involving MODIS satellite data for aerosol optical depth, optical cloud thickness, ground station and aircraft LIDAR data, air quality data from the Community Multiscale Air Quality Model, short-term forecasting, and a large quantity of data and wind vectors from a model. This project is intended to demonstrate the ability to produce useful short-term forecasts (2 to 3 days) and the ability to incorporate satellite data. The process to develop this single use application involved meeting with stakeholders to establish requirements, locating and copying all input data (huge quantity and effort), deciphering file form and content, writing converter programs, developing visualization code, rendering frames of animation, and compositing various sequences into one movie.

How can this be improved? Suggestions include organizing and cleansing subset data at the source, subsetting the data to identify only what is needed and reduce disk space needed (by several orders of magnitude), and checking and fixing effective data. Also critical is the need to complete the metadata; an example is that some temperature data had no units, so it was not known if the value was Centigrade or Fahrenheit.

Assimilation is harder than visualization. Temporal sampling can be instantaneous or averaged. Visualization displays the most recently available data, but assimilation must do careful linear interpolation or resampling. Spatially, visualization can take data from different models and different projections, unproject it into latitude/longitude, and then reproject it elsewhere. However, in assimilation,

the polygon intersection problem must be addressed, so it is necessary to do kriging and address data differences. Different techniques apply if the data are continuous, but addressing discontinuous data is more difficult and interpolations must be made. As a result, it took the project team over a year to get one data file corrected and the visualization still came out suspect.

Grand initiative projects involve a variety of organizations and users that access, for example, NOAA, NASA, and other data via an integrated server. This is a challenge because it involves an array of independent data creators/owners, integrators, and users looking at results. While online data catalogs like EIMS already exist, there is the need to create web servers to support this approach. Challenges include wall clock time efficiency, memory efficiency (e.g., local caches of data and avoiding creation of accidental copies of data, which can add extra storage, buffers, etc.), efficient access to streaming subsets, and powerful, convenient data models important to building successful projects.

A last example involves field data models. Issues include fundamental metadata standards; information needed to write the code (e.g., dimensionality, category, rank, shape, byte format), validity of data and units, range/magnitude (the latter is not often provided and must be calculated), time stamping, and accuracy. There are two approaches. The federated approach involves extraction of data, describing the data sets, and writing a model to address these data aspects, which results in an explosion of complexity. The second, more preferred, approach is to provide custom streamers of different formats with the streamers mapping onto a single, unified data model. This is for future, rather than legacy, applications.

Sophisticated, robust models, such as cross-media, human health effects, and decision support systems, require cooperation among data owners as well as a high quality data model and the software to support it. For this, streamers are recommended to convert data "on the fly" and subset it. This requires cooperation from all of the organizations involved as well as long-term stable funding.

Multi-data set visualization is exciting but not trivial and is not easily automated. In today's state-of-the-practice, visualizations are either turn-key applications or throw-away, one-shot applications. Both are programmer-intensive efforts, require detective work, and are not amenable to automation. Assimilation is harder and is limited to pre-processed, carefully replicated file copies. Architectures, web servers, powerful data models, and software are needed to address these technical hurdles. There is an associated problem of creating metadata that benefits users at no cost to them; this creates an inequity inherent in the system. As a result, metadata are often just "copied and pasted" from elsewhere and may not have sufficient quality. This is an issue that must be dealt with—metadata cannot be retrofitted after the fact to get quality. It is also necessary to pay attention to effectiveness and performance, especially for distributed high performance computing applications and visualization. The biggest hurdle is stable, multi-year funding across multiple agencies.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) how the publication of fraudulent data purporting inaccurate scientific relationships (e.g., combined cell activation represented as synergism) can lead to inappropriate conclusions and questionable regulation; (2) the need for high-level organizational support of sharing, cooperation, and training to promote use of data visualization; (3) the increasing importance of metadata and actions within OEI to address data quality, metadata needs, and acquisition of standard data sets for EPA databases; (4) how metadata is perceived as a tax on data owners and the need for metadata to support data sharing and collaboration; (5) the difficulties in metatagging concepts and a broad view by many that metadata do not have value; (6) how creating a requirement to capture metadata does not translate into accurate or meaningful completion of the required fields; (7) the difficulty of obtaining raw data underlying information in published journals, the

possibility of creating a data repository that could contain such information, and challenges encountered in firewall access and information sharing with an example drawn from NIH where rules for data sharing that may not been working as desired; (8) more involvement by ORD to assist regions and states with data collaboration, including an example of collaboration between EPA Region 10, NOAA, and OEI in plume modeling for fire seasons in the western U.S. that may be applicable to other efforts; and (9) how the data grid and Science Portal projects may provide incentives for researchers to develop and supply the necessary metadata.

Environmental Information for Decisionmaking: What Does the Science Say?

Following opening remarks by Matthew Clark, with NCER, six speakers addressed the use of environmental information to make decisions and change behavior, case studies of how TRI data have been used to effect change, how changes in TRI reporting thresholds affect interpretation of the data, whether better beach monitoring and notification can result in health benefits, the effect of green labels on consumer preferences, and behavioral responses to ozone alerts. An audience question and answer period followed the presentations.

EPA and the Science of Information Use

Matthew Clark, with NCER, discussed how ORD is looking at linkages between science and behavior and how people look at certain types of information. Environmental information has been touted as the third wave of environmental policy after command/control and market approaches. The idea is that if all of the information that people need is provided, people can take care of themselves. Examples of environmental information provided by EPA include TRI (one of the biggest), drinking water consumer confidence reports where utilities send information on drinking water to customers, color-coded ozone alerts, beach alerts when microbial or other contamination is present, labels/certifications/awards such as Energy Star, and compliance information.

The basic research questions are:

- Who uses the environmental information?
- How does this change behavior/decisionmaking?
- What changes in environmental or economic performance occur?
- Who benefits and by how much?

Examples of who uses environmental information include:

- Firms or facilities to improve environmental management and bottom lines
- Financial markets to evaluate liability
- Communities to take action
- Consumers to influence purchase choices (e.g., buying green)
- Regulators to target violators and allocate enforcement resources more efficiently.

If no one uses the information, it is not worth collecting.

The Uses of Toxics Release Inventory Data

Gail Froiman, with the Environmental Analysis Division in OEI, presented examples of how the TRI information has been used and how facilities have tried to reduce releases (either voluntary or under pressure) once this information became public. The TRI program was one of the first to teach about the power of environmental information and the ability to affect change in ways that may not have been

predicted. The TRI program was developed in response to the Bhopal, India incident that killed many people outside of the plant to address the question whether this could happen in the U.S. Initially, facilities were required to report on releases for 300 toxic chemicals and this is now expanded to 600. The TRI program is different from other EPA programs in that releases address air, land, water, offsite facilities, and offsite landfills, and facilities are not required to reduce releases. The reporting is triggered by the amount handled, not by the amount released. This helped EPA to learn more about these facilities than it knew before. This is a powerful and interesting way to cast a net for information that is different from many of the other environmental statutes. Industry, government, financial services, and international organizations all use these data and academia is often found as a component of all of these. Several examples were provided to illustrate how different kinds of institutions have influenced environmental change and generated environmental improvements using TRI data.

In the early days of TRI reporting, the State of Louisiana had the largest rate of release per capita per square mile per unit of economic output. A company wanted to build a commodity chemical facility in Louisiana and made estimates of releases for the proposed project. Using information from TRI for similar facilities, the Louisiana Environmental Action Network was able to refute what the company reported and this resulted in the facility opening in a different location and with more controls for releases than the statutes required.

In Wisconsin, paper production generates the most releases. The Oneida Tribe looked at TRI data and convened a conference with paper manufacturers and other organizations to get everyone to work together to reduce releases. In addition to improved education and networking, one of the labor unions made reduction of releases part of their negotiations.

The Ecology Center, a non-governmental organization (NGO), looked at TRI data and noted trends of increased emissions in a specific industry. The NGO met with industry and local community representatives to negotiate process changes and an agreement to reduce the emissions from specific plants.

Environmental justice is a program that evaluates whether certain socioeconomic groups are more exposed to toxic chemicals than others. In Los Angeles, Communities for a Better Environment combined 1996 TRI data with GIS mapping data to demonstrate that this was occurring.

The Haartz Corporation uses petrochemicals to make fabrics used in convertible tops. From the TRI reporting, the company was surprised by amount of emissions in their processes and made changes that saved in $200,000 per year through improved control of methyl ethyl ketone emissions. Note that some rule changes as a result of a lawsuit may require methyl ethyl ketone to be removed from TRI list as it is an ozone precursor not problem in and of itself; EPA may also take all chlorofluorocarbons off the TRI list for the same reasons. As result, there can be inconsistencies in the data set that can be confusing in analysis.

As an example of government use of TRI data, the State of Indiana asked companies to voluntarily reduce TRI emissions by 50 percent between 1995 and 2002. They found that often it is not hard to reduce emissions if the company is willing to commit capital to the project.

An area that generated the most surprise as an important impact of dissemination of environmental data is in the financial industry. There are some mutual funds that limit themselves to what they consider to be environmentally sound firms. There is now, more recently, a Dow-Jones Sustainability Index that incorporates TRI and other data to monitor sustainability performance of corporations. Similar (but not identical) TRI programs have been spawned in other countries; some are waste-based rather than chemical-based and these results are used in the Dow-Jones Sustainability Index.

EPA is in the process of re-engineering the TRI system and it is anticipated to be online October 1, 2005.

The Effect of TRI Reporting Thresholds on Data Quality

Lori Bennear, Assistant Professor of Environmental Economics and Policy at Duke University, discussed the use of TRI data in evaluating performance and the impacts of reporting thresholds on the data. On the policy side, there are two new rulemakings to reduce reporting burdens and there is discussion about increasing reporting thresholds for some TRI-listed chemicals. There is limited understanding of the effect of reporting thresholds on the validity and value of TRI data.

This research project focuses on facilities that report under TRI because they manufacture/process 25,000 pounds or otherwise use 10,000 pounds. Central research questions involve: (1) how much of the observed decrease in toxic releases (e.g., how much of the trend over time) is attributable to reporting thresholds, and (2) how sensitive are rankings (good, fair, and poor) to reporting thresholds. The fundamental problem is that we do not know how much a company is still releasing if they stop reporting—Are they using the chemical at lower levels? Not using it at all? Thus, the question is how to figure this out for facilities below the reporting level.

To address this question, data were used from reporting under the Massachusetts Toxics Use Reduction Act (TURA), which is similar to TRI; TRI data are a subset of TURA data for Massachusetts facilities because they must report more information under TURA than under TRI. Under TURA, facilities were asked an optional question about why they stopped reporting a chemical and facilities were required to report chemical use as well as chemical release. In addition, the Massachusetts thresholds are weakly lower than federal thresholds; if a Massachusetts facility has to report for a single chemical based on federal thresholds, then TURA requires that they report on every chemical that they manufacture, process, or otherwise use in quantities greater than 10,000 pounds.

Data from the optional question were used to estimate the magnitude of releases still present for a facility that ceased reporting because it went below the reporting threshold. These were included in total releases and the project measured the effect of including the missing releases using time series and cross-sectional analyses. The data cover the time period 1990 to 1999 and involve 23,200 total chemical reports and 3,758 cases where a facility stopped reporting a chemical.

For facilities that stopped reporting to TURA, about one-third answered the optional question. There were multiple choice options for answering the question, and the largest response was that the facilities were still using the chemical but were below the reporting threshold. This left the question as to what happened to the two-thirds who stopped reporting but did not answer the optional question. The most important predictor in answering this question was how far the facility was from the reporting threshold the previous year. For example, a facility that is just above the 10,000 pound threshold could drop below that by implementing a few manufacturing changes.

To estimate the magnitude of missing releases, statistical analyses were conducted to impute the data for facilities that stopped reporting. This was restricted to core chemicals and industries, and both on-site and total releases were evaluated. This resulted in three estimates: a lower bound (releases for nonreported chemicals are zero), upper bound (releases for nonreported chemicals are equal to the last reported value), and a linear projection (releases decline over time at same rate as observed for reporting chemicals). Graphs were presented that showed trends in total releases and the curves for the three estimates were very similar. Using the lower bound estimate, releases were reduced by 54 percent; using the upper bound estimate, releases were reduced by 31 percent; and using the linear projection estimate, releases decreased by about 36 percent. The true value is not known since there are no data for nonreported

chemicals. In this case, about 40 percent of the decline seen in reported releases could be related to reporting thresholds.

To make inferences about relative performances of facilities, the facilities were divided into four quartiles to compare total releases. Then, a ranking (excellent, good, fair, and poor) was calculated using both the lower bound and upper bound assumptions, with the greatest interest on big movements in the data. About 31 percent of the facilities ended up in a different quartile when the missing releases were considered. The study also found that about 21 percent of the poor category (lower bound assumption) would have been labeled as something better if the unreported releases were considered and about 61 percent of the facilities labeled excellent (lower bound assumption) should have been ranked lower if the missing releases were included. Thus, it is better to target the "poor" facilities to talk to them about improvement rather than the facilities in the excellent ranking that are more subject to manipulation around the threshold value.

These analyses are for Massachusetts and the right data do not exist to examine the threshold issues at the national level. There is some evidence of reporting threshold impacts at the national level from the examination of lead and mercury information. For example, lowering the reporting threshold for mercury resulted in 20-fold increase in reporting facilities and a 33 percent increase in emissions reported for mercury. Lowering the reporting threshold for lead resulted in a four-fold increase in reporting facilities and an 18 percent increase in emissions reported for lead. In addition, a colleague examining distribution of mercury exposure under the Maximum Achievable Control Technology requirements under the Clean Air Act (CAA) and the potential Tradable Permit Standards for utilities found several large mercury emitting facilities in North Carolina that are not utilities. Thus, applying the new mercury regulations for utilities would make no change to the mercury emissions situation in North Carolina. To find this required data for the year 2000 after the reporting threshold changed; this would not have been found using the 1999 data.

This study shows that reporting thresholds do matter. There are costs to collecting and reporting data, but the benefits are better targeting of resources and better assessment of progress. Reporting thresholds affect our ability to do both. Any effort to increase reporting thresholds is potentially going to have real impacts on our ability to use these data to do the types of analyses we need to do to make better policy. The final implication is that analysis would not be possible without data from the TURA program; since there may be as many as 50 different state experiences running at the same time, an analysis of state metadata could inform policy design for national information collection.

Does Better Beach Monitoring and Notification Improve Benefits?

Julie Hewitt, with the National Center for Environmental Economics in the Office of Policy, Economics, and Innovation, discussed beach monitoring for health-related contamination, new testing methods, and their impact on notifications and associated health benefits. Pathogen contamination at beaches puts swimmers at risk for gastrointestinal illness through contact with pathogens. Pathogen contact is often related to rainfall, combined sewer or sanitary sewer overflows, and nonpoint runoff from land-based sources.

Monitoring for indicator bacteria supports decisions to close or post warnings at beaches that typically occur at the beach management level (e.g., local health department, state park, or federal park). However, it takes 24 hours or more to get test results on pathogen levels with current test methods. A chart illustrating the change of water quality (good, bad, then good after event passes) overlaid with sampling, analysis, and beach closing/opening events demonstrated that use of current analytical methods results in lag time to obtain analytical data and further results in lags in decision timing to close the beach; as a result, the beach is largely open during the actual event and is closed for a period after the event over.

ORD has developed new test methods, such as quantitative polymerase chain reaction (QPCR), which is deoxyribonucleic acid (DNA)-based and requires only 2 hours to obtain results. Use of the new methods can reduce the time to obtain analytical results for decisionmaking and can reduce the time in which the beach might be open but ought not to be.

The National Epidemiological and Environmental Assessment of Recreational (NEEAR) Water study conducted by EPA collected data in 2003 for two Great Lakes beaches—one on Lake Erie near Cleveland, Ohio, and one on Lake Michigan in Indiana. This included an intercept survey of beachgoers to determine specific actions taken (e.g., put head in water, go to beach but not go in water, etc.) that helps to understand the degree to which beachgoers are exposed and get sick from the waters. There also is a follow-up survey to see if beachgoers contracted gastrointestinal illness after being at the beach. The study included water quality testing using both current and new methods; samples were taken the same day as the intercept surveys.

Other information used in this study included EPA's Beach Advisory and Closing Online Notification, which is found on EPA's "find your beach" web site (at http://oaspub.epa.gov/beacon/beacon_national_page.main) and is used to find the exact dates of beach opening/closing as well as historic data for the same beach; beach attendance data from beach authorities (overall, not just those in the intercept survey); and rainfall data from NOAA. Cost-of-illness data for gastrointestinal illnesses and economic values of avoiding impaired water quality warnings were used to estimate economic benefits. Cost of testing was also considered in the analysis.

Preliminary results show that the new test methods could achieve annual health benefits. The study found 15 days that the beaches were open but should have been closed and predicted 819 avoided cases of gastrointestinal illness. Using an estimate of $247 in avoided costs per case resulted in estimated total health benefits of $202,000; this is the cost of illness (not willingness to pay) for those two beaches for 1 year. Annual recreational benefits were also estimated for the 15 days that the beaches were closed but should have been open. These are relatively popular beaches with about 3,248 swimmers each day. At $2.28/swimmer on an avoided beach advisory day, total recreational benefits were estimated at $62,000. The total net cost for the new method (including capital costs, training costs, etc.) was about $2,000 at the two beaches (annualized). Therefore, annual net benefits at these two beaches were estimated at $262,000.

The answer is that benefits can be improved and quite significantly. Health benefits are much larger than recreational benefits for these two beaches. It is possible to defer a trip to the beach trip if it is known to be contaminated (therefore, defer the recreational benefit), but it is not possible to defer the illness effect. The benefits will vary spatially based on rainfall level, beach attendance, etc.

Future directions include extrapolation from these two beaches in the NEEAR study to other Great Lakes and freshwater beaches, as well as to marine beaches, if possible. The new analytical method may have a lower level of false positives, which requires further evaluation before this claim can be made. Other activities include the use of GIS tools to centrally place testing facilities; these facilities are expensive and need to be located so they are as close to as many beaches as possible that are only 1 hour away. Researchers also want to target beaches and times to test (e.g., weekday vs. weekend day) because these may vary dramatically across beaches in the U.S.

The Effect of Green Labels on Consumer Preferences

Mario Teisl, with the University of Maine, discussed how the psychological characteristics of individuals interact with environmental information drawing on a project involving the Maine Department of Environmental Protection and the Maine Automobile Dealers Association. The State of Maine passed

legislation for a voluntary program to ecolabel cars and trucks in the State. The project team collected baseline data before the marketing campaign for this program begins (the focus of this presentation) and is also set up to collect survey and sales data after the campaign begins.

Studies in environmental psychology have shown that the following affects purchases:

- Environmental concern level (i.e., the consumer has to be concerned)

- Perception that their consumption patterns matter; this is based on knowledge of the market and environmental problems, and involves perceived consumer effectiveness (i.e., must think that their individual decisions matter)

- Faith in eco-behavior of others; there is some social peer pressure effect in that if a consumer thinks that others are doing it, they will do it, and there is the opposite effect that if others are doing it, they think that they do not have to do it

- Perceived compromise which involves questions such as: Are these products as good as others? More expensive? Safety issues? Good performance?

A mail survey was sent to those who registered vehicles in Maine and there was a 60 percent response rate. The survey collected information on opinions, knowledge, vehicle types and use, among others. This was set up as a two stage conjoin experiment. In the first stage, respondents made a choice of vehicle class; in the second stage, they made a choice of vehicle within that class. At each stage, the research team sought price, miles per gallon, and pollutant and global warming scores.

The starting model has vehicle class choice being driven by the importance of commuting and capability of hauling (e.g., work or recreational). This included data on income, annualized purchase price (including annualized payment of car/class as well as maintenance, taxes, licenses), annual cost of driving (knew from survey how many miles driven per year, miles per gallon, price of gasoline), and criteria pollutant and global warming scores, which interact with some of the psychological factors such as perceived consumer effectiveness, faith in others, and a knowledge (or "ignorance") variable. In responding to questions on how much a vehicle pollutes when driven (by class of cars), there was an option that almost all vehicles contribute the same; while this is not true, about 7 percent of the sample thought this was true. In addition, "green" was seen as good substitute.

The "faith in others" factor was found to have both a peer effect and "faith in others" aspect. Aspects thought to measure peer effect (e.g., thinking others are willing to do their part to save environment, willing to pay for greener product) also resulted in unexpected responses such as believing that scientists will solve environmental problems, trusting the State to deal with this so "I don't need to worry about it," etc.

In developing the final model, all of these psychological interaction terms did not matter at the class choice level, so they were dropped. At the vehicle choice level, the interactions involving global warming did not matter (i.e., respondents had homogeneous reactions to ecoinformation in this area) and were dropped.

Regression analysis results were presented for car, sport utility vehicle, and truck, and demonstrated that the final model was working well. At the class choice level, use drives vehicle class choice decision and people have a general feeling of what a good price is. On the vehicle choice decisions, almost everyone made greener choices. Some factors are jointly rather than individually influential.

A major finding was that consumers were uniformly concerned about global warming even when saying that they do not worry about it. For criteria pollutants, consumer response was heterogeneous. One observation is that media coverage of the last few years has focused on global warming, not criteria pollutants and their health effects, and one reason for this may be that criteria pollutants are already regulated. This is an interesting interrelationship. On a project about genetically modified foods, it was hypothesized that when things are regulated, the benefits of additional information decreases; this is consistent with the findings from the vehicle study.

The information from this survey helped to design the marketing campaign such as what consumers to target and what message to deliver.

Behavioral Responses to Ozone Alerts: Estimates of the Value of Children's Health

Carol Mansfield, with Research Triangle Institute International, presented study findings indicating that people do use the ozone alert system to make behavior changes on a day-to-day basis and that having to stay indoors as a child imposes costs (such as hardship on parents) that are not measured in traditional cost-benefit analyses. The AQI is a color-coded warning system that includes recommendations on activity restrictions and is widely publicized in television and elsewhere.

This study surveyed parents as to their knowledge of ozone alerts (i.e., AQI warning), how they change their child's behavior on ozone days, whether families with asthmatic children do different things from those who are not asthmatic, and whether the measures taken are effective in reducing health risk. In terms of policy or science implications, if people change their behavior in response to AQI warnings, then studies that link ozone data and hospital admissions may be underestimating health impacts and benefits of air quality improvements will be understated. Differences in awareness and behavior help to identify opportunities for different health interventions.

This pilot effort was not intended to be a nationally representative survey. This involved a self-selected panel and participants had to be in the 35 highest ozone Metropolitan Statistical Areas (MSAs), the children had to be 2 to 12 years old, and there had to be one stay-at-home parent in order to have someone making decisions on the child being outdoors and to know what the child was doing. The study involved 979 households, of which 473 had children with asthma. Participants received a web-based, time-activity diary survey that was sent on specific days. The project team monitored weather conditions, told the survey company specifically when to send the email, and closed survey response after 48 hours. While the goal was to have diaries for three Code Red days and three Code Green days, not all locations had three Code Red days; it was also important to keep within a specified temperature range because of the linkage between ozone levels and temperature.

Participants were recruited and received the baseline questionnaire in June 2002; about 95 percent of qualifying households took the baseline survey. About 20 percent of the households completed all six activity diary surveys, over 70 percent completed at least four, and about 79 percent completed at least one during July through September 2002. About 48 percent completed the final survey in April 2003 that asked about understanding of ozone alert levels, what was done when air pollution was high, and how worried they were about air pollution; prior surveys only asked about activities of the children.

Activity diaries included the child's daytime activities according to a list of 20 activity categories from the EPA Consolidated Human Activity Database. Participants were asked to record the duration of each activity, level of activity (e.g., sleeping, walking), what proportion was indoor/outdoor and home/away, daily symptoms, medication use, asthma status in the last week (e.g., went to hospital, doctor, or

emergency room in the last week), and whether the child spent more or less time outdoors than usual and why.

Asthmatics, as a higher percentage, spent more time in outdoor sports on a weekly basis. The median value for all children was 3 hours a day for television viewing. For the asthmatics, about 44 percent experienced symptoms year round and about 12 percent experienced symptoms in summer; triggers included change in weather (53 percent), exercise (41 percent), and air pollution (31 percent).

For those who completed at least one diary, the average age of the child was 7 years, 46 percent were asthmatic, 58 percent were male, and 88 percent of the parents were white. The average income was approximately $66,100, which is close to census data seen for one wage earner families in the general population.

The final survey asked whether the participant checked ozone daily. Parents of asthmatic children were more likely to check ozone daily and parents of asthmatic children were least likely to never check ozone alerts. Parents of asthmatic children were more likely to say that they reduced outdoor time on high air pollution days. The probability that parents check the ozone forecast gets higher with the severity of the child's asthma.

In analyzing the activity diary data, about 1.5 hours were spent on average outdoors; about 48 percent of the children spent the entire time outdoors. Researchers found that asthmatic children are changing time outdoors and nonasthmatic children are not. In cities with more ozone days, children spend less time outdoors. In general, parents reported high awareness of ozone alerts.

Future activities include additional analyses of the activity diary data, adding the study data to the EPA Consolidated Human Activity Database, and designing a national survey on awareness and behavior for EPA to start tracking this information over several years. There is also the desire to incorporate this data into a policy simulation model to see changes in behavior and health effects/impacts.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) that swimming was not an outdoor activity considered in the children's survey of activities during high ozone days in order to remain consistent with the Consolidated Human Activity Database designations for outdoor activities; (2) the difficulty of generalizing the findings from the Massachusetts TURA data analysis when two-thirds of the facilities did not respond to the question on why reporting ceased, the ability to ascertain that nonreporting is making some difference, and the difficulty in discerning whether nonreporting is making a large difference; (3) the use of random sampling to select 1,100 residents (and vehicle types) to receive vehicle surveys in Maine of which 628 were returned; (4) how nonmarket valuation includes both stated and revealed preferences and the greater acceptance of stated preference data over revealed preference data; (5) recent OMB guidance on how to conduct cost-benefit surveys for federal regulations, including stated preference surveys as well as pending recommendations on surveys and data collection efforts; and (6) the importance of comparing/measuring things that we care about rather than comparisons for the sake of measurement.

Collaboration and Comparability in National Water Quality Monitoring Programs

Following opening remarks by Chuck Spooner, with OWOW, four speakers addressed the development of a national monitoring network, challenges in sharing water quality monitoring data, assessment of

wadeable streams at the national level, and selection of analytical methods using NEMI. An audience question and answer period followed the presentations.

Developing a National Monitoring Network

Chuck Spooner, with OWOW, provided an overview of efforts involved in developing a National Water Quality Monitoring Network. The origins of the proposal to design the National Monitoring Network begin with the *Ocean Blueprint for the 21st Century*, a final report of the U.S. Commission on Ocean Policy and *The U.S. Ocean Action Plan*. The Council on Environmental Quality and the National Science and Technology Council worked together to produce a more detailed charge that gave the National Water Quality Monitoring Council the challenge to create a national water quality monitoring network. The National Water Quality Monitoring Council has 35 members, including EPA, USGS, and NOAA, and works through the Advisory Committee on Water Information (ACWI), which is chartered under the Federal Advisory Committee Act. There were three recommendations: (1) develop a network that coordinates and expands existing networks, (2) include coverage of both coastal and upland areas and link them to the Integrated Ocean Observing System, which is in development, and (3) must have clear goals, specify core variables, an appropriate sampling framework, and be periodically reviewed and updated.

A nine member steering committee oversees development efforts. There are several work groups addressing design, inventory, methods and data comparability, and data assembly and access. There are 57 participants: 40 percent federal, 28 percent state/tribal, 23 percent academia, 7 percent industry, 2 percent local, and 1 utility in California.

The challenge faced in defining the National Monitoring Network is defining common information goals, compatible design approaches, sample timing, metadata standards, parameter specifications, field data collection and handling, analytic procedures, and data storage and access practices. Meeting these challenges will involve specific analytical locations and sampling procedures as well as performance standards for metadata and expectations for network participation.

The approach to date is to design the Network using very specific goals and objectives linked to management questions. The design will be compared to existing monitoring networks then specific features will be retained, added, extended, enhanced, or defined as external to the network. The goals are to integrate, coordinate, and enhance water quality monitoring efforts to make informed management decisions for sustainable use of aquatic resources. This is not a technology-driven effort and the intent is to communicate that there is quality-assured data available to address national, regional, state, and local needs. The five objectives are to:

- Define status/trends of key water quality parameters and conditions nationwide
- Provide data to determine whether goals, standards, and management objectives are being met
- Provide data to target more intensive monitoring, preventive actions, or remediation
- Provide data on coastal oceanographic and hydrologic research, including freshwater inflow influences
- Provide quality-assured data to prepare interpretive reports and educational materials.

The work has been narrowed to six environments and may include a seventh. The backbone of the upland system involves the major river systems and major tributaries of those primary drainages.

Efforts will be conducted in association with regional Integrated Ocean Observing System associations, which are not all yet formed. Several case study areas will serve as the principle method of addressing the scale issue: the Gulf of Maine (the Northeast), the Chesapeake Bay (the Mid-Atlantic area), Gulf of Mexico, Mississippi River, and Pacific Northwest (fisheries-related issues). The project has started to look at relative discharges of these rivers because nutrients and nutrient-related problems are increasing and are proportional to discharges.

The Chesapeake Bay was presented as an example of the challenges faced in this effort. Historically, this region is very heavily studied and has many stream gages (703) as well as 1,700 water quality stations that have existed over time. Today there are only 313 active stream gages and 389 active water quality monitoring sites, but there are only 176 that provide both water quality and stream gage data, and only 118 of those meet the frequency and/or parameter criteria for trend analysis. This is an example of how monitoring sites are formed that meet reasonable qualifications to become members of the network.

Another area of focus is the issue of oxygen depletion. Parameter lists have been assembled for marine and estuarine water, and efforts are underway to contact other case study areas to see what is already being done to determine what already can be included as part of the network and to determine what else is needed. The Network is anticipated to receive federal funding; the investment is already high (hundreds of millions of dollars each year by public agencies), but is not high enough (only about half of what the investment should be). Efforts are focused on putting together a fully-funded program to do the job right.

Efforts are also underway to address common definitions of environmental compartments, common information goals, common parameter specifications, and metadata standards. Methods for common information goals and use of different design approaches have been discussed. Future activities will address field data collection and handling, analytical procedures, and data storage/access practices. Interim progress will be reported to a National Water Quality Monitoring Council meeting in the fall, the draft report is due to ACWI in September 2005, and the final report is due in January 2006.

The National Water Quality Monitoring Council sponsors a monitoring conference every 2 years. The next one is scheduled for May 2006 in San Jose.

Water Quality Data Elements to Facilitate the Exchange of Monitoring Data

LeAnne Astin, with the Interstate Commission on the Potomac River Basin, discussed activities of the Water Quality Data Elements Work Group under the Methods and Data Comparability Board for the National Water Quality Monitoring Council. The National Water Quality Monitoring Council urges monitoring entities to work collaboratively and strive for methods and data compatibility to assess water accurately, efficiently, and effectively. Integration of data from different monitoring programs allows the emergence of information that cannot be obtained from individual efforts, and documentation of data quality and characteristics enable exchange of information of comparable quality across programs.

Background discussions included the benefits of sharing water quality data, barriers to sharing water quality data, and the lack of documentation for analytical methods and statistical tests that impact interpretation of results. Good data management and organization was noted as critical to facilitate data exchanges. However, some agencies do not want to exchange their water quality data. In addition, data often reside in paper or computer files, not centralized systems. While more and more content is being made available on the Internet, the data can be of questionable reliability or may be difficult to find using conventional Internet search engines.

To be useful, water quality data need to be found and understood. This requires documentation using a systematic method to describe the data and improve access to it. Metadata is key descriptive information

that documents data sets or information products by documenting what is collected, how, when, where, and by whom, as well as the accuracy of data, availability, and distribution. A data element or metadata element is a unit of metadata and includes a name, description, and other information such as field type or domain. Creating content for these elements to facilitate online searching is called tagging. Many scientists resist writing metadata, and monitoring budgets often do not include the costs of data curation and maintenance. However, the lack of metadata is an impediment to data sharing.

Water quality data elements are the core elements that give users information to make informed decision as to quality of data and comparability of the data for their purpose—the who, what, when, where, why, and how. A goal of the Water Quality Data Elements Work Group is to develop and recommend a core set of data elements for voluntary implementation to structure the sharing and archiving of water quality data and will hopefully allow data to be compared regardless of monitoring activity purpose. This involves a modular approach with each module representing a category of metadata information (e.g., who, what, when, etc.).

Lists of data elements have been developed for different water quality monitoring "disciplines" such as toxicology, population-level assessment, chemical and microbiological assessments, etc. The goal is to integrate these into a comprehensive water quality monitoring program. Many elements are common to all monitoring data sets and each list also contains elements specific to the requirements of that discipline. This organizational framework allows changes to be easily made or for organizations to customize the data elements to meet their monitoring needs. For example, the Environmental Data Standards Council used the Chemical/Microbiological Water Quality Data elements as a starting point for the ESAR data standard. The Wadeable Streams Assessment project is recommending that the water quality data elements for population/community data be used for data reporting that supports their comparability evaluations. In addition, the biological and toxicological data elements have already been adapted for use by other state and interjurisdictional monitoring activities.

Monitoring data can be better managed to facilitate data exchange if objectives are clearly and precisely defined. The objectives determine the monitoring design which drives the analysis which affects reported results. Thus, the issue of data comparability arises when data are shared across monitoring programs. Comparability of data is user-defined—is it suitable enough for my purpose? There are two levels of comparability when looking at multiple data sets: raw and indicator. If the raw data are available, comparability can be examined using powerful, robust statistical analyses and this requires background information on methods performance. At the indicator level, there are some statistical methods for accomplishing heterogeneity in data quality due to survey differences in methodology and design. Meta-analysis is a systematic statistical review *"…of a large collection of analysis results from individual studies for the purpose of integrating the findings*." Two methods are those dealing with relationships between variables (i.e., correlations) and those concerning differences between means (i.e., effect sizes). Meta-analysis is used in the medical and psychology areas but it is just beginning to be used in ecological studies. Frequently, only summary statistics are available. However, robust statistical combination of independent documented results requires information such as the description of study/sample design, acceptability criteria of data being integrated, bias, sensitivity, data quality information, and sources of heterogeneity. All of these considerations (for raw and indicator data) are incorporated in the water quality data elements by the Water Quality Data Elements Work Group.

Data of "documented quality" is needed to evaluate comparability. Data documentation (with tagging) facilitates online submission and exchange of data, which gets back to the main purpose of the water quality data elements effort—making sure data can be found and understood. The water quality data elements are intended to be customizable, and a guidance document in review by ACWI should be available shortly.

More information is available at http://wi.water.usgs.gov/methods/tools/wqde/index.htm.

Wadeable Stream Assessment Comparability Studies

Laura Gabanski, with OWOW, presented an overview of the national Wadeable Stream Assessment project. Recent critiques about water quality monitoring in this country are that the states do not have the data needed to make decisions, set water quality standards, establish cleanup goals, or determine if management actions are meeting goals. In addition, there are concerns that we do not have the data to make statistically valid statements about the water quality condition in the U.S. The vision for the future is that there is adequate monitoring data to assess water quality and make sound watershed management decisions. This requires partnerships and development of the best monitoring tools to answer key questions at all scales—national (important to EPA and country), regional, and local scale (to implement programs). This must be done as efficiently and cost-effectively as possible.

The Wadeable Stream Assessment project supports collaboration with states and tribes to produce a statistically valid assessment of the nation's waters, expand accessibility and use of data, and promote partnerships. This project will provide results at ecoregion II scale, national scale, and some state scales. Approximately $7 million in funding in FY03 and FY04 supports the preparation of a statistically valid report on the condition of wadeable streams at several scales and focuses on a basic set of core indicators. Efforts are being funded through cooperative agreements and are taking advantage of work done with the Western Environmental Monitoring and Assessment Program (EMAP) for the Western U.S.

The key components of the Wadeable Stream Assessment are: randomized site selection design, ecological assessment based on macro-invertebrates, quantitative physical habitat characterization, and basic water chemistry (nutrients, suspended sediments, cations, dissolved organic carbon). There is a comprehensive quality assurance/quality control program involving eight to 10 laboratories, standardized/centralized data management, and an analysis plan for ecological assessment that will undergo peer review. Sampling is being conducted of first to fifth order wadeable streams at the ecoregion II level; there are about 750 sampling stations (about 50 per ecoregion II level).

Cooperators were encouraged to propose enhancements and about half of the cooperators identified comparability studies, such as comparing state methods side-by-side with wadeable stream assessment methods. Some states wanted to test other indicators such as fish assemblages and periphyton assemblages, and Iowa, Virginia, and Wisconsin identified state scale efforts.

A data assessment work group was put together early in the project to develop data analysis options given the difficulties in analyzing data as a result of the variation encountered in an area of ecoregion II size. There was considerable debate on data analysis options and options were presented to cooperators at a national meeting in January 2005. Four work groups were formed to analyze the monitoring data: physical habitat, chemistry, gradient streams, and reference sites. A regional workshop will be held this summer to analyze data, the analysis plan will undergo peer review, a draft report is to be completed by September 2005, and a final report is to be completed by December 2005.

Some of the data analysis and interpretation options being considered include basic descriptive statistics that have been used before in these kinds of studies as well as analysis and interpretation in terms of "good, fair, or poor." To illustrate the latter approach, a map was presented that showed preliminary attempts to identify the proportion of perennial stream miles that are in good ecological condition. Another effort is to develop the relative importance of stressor information being collected and to determine relative risk to macroinvertebrates.

EPA is also working with the states, USGS, other cooperators, and the Methods and Data Comparability Board to develop guidance on performance-based assessments as well as rules for combining data and depicting the national assessment. The goal is to see if existing state data are sufficiently comparable to each other and to the wadeable stream assessment so that they can be aggregated to form a national assessment. This will involve comparisons of protocols, data, metrics, and indices at the assessment level.

Sampling for the Wadeable Stream Assessment involves a minimum of 20 sites sampled over a 2-year period. Ten of the sites are reference sites and the other 10 sampling sites are trying to capture stressor gradient and natural disturbance gradient information. Sampling is conducted within well-defined stream segments between two confluences with no major water quality changes; the stream segment must be long enough to implement the methods being compared and to accomplish the required duplication. Sampling points are selected between/among the procedures so that the same method is not always downstream of the others. Strict adherence to standard operating procedures and quality control procedures is required to minimize sampling bias, and this is documented by all participants.

This summer, a cooperators work group will meet to look at data collected so far and determine if state reference site data can be used. The Wadeable Stream Assessment report, due in December 2005, will include analysis of completed comparability study data.

Comparability in Analytical Methods Selection Using the National Environmental Methods Index

Eric Vowinkel, with the USGS and New Jersey Water Science Center, presented the capabilities of NEMI—a collaborative product of the National Water Quality Monitoring Council's Methods and Data Comparability Board, which includes many federal, state, tribes, local government, university, and private sector groups. NEMI is a user-friendly web-based tool maintained by the USGS that provides one-stop shopping for publicly available methods and allows for rapid search and retrieval to compare and contrast the performance and relative cost of analytical, test, and sampling methods for environmental monitoring.

The information in NEMI comes from EPA, USGS, Department of Energy (DOE), NOAA, the American Society for Testing and Materials (ASTM), international sources, Association of Official Agricultural Chemists (AOAC), standard methods, and private companies. NEMI currently includes over 725 methods: 250 from EPA, 150 from USGS (plus 80 in a staging area), 20 from NOAA, 32 from DOE, 75 from ASTM, 8 from AOAC, and more than 100 standard methods. The web page provides the opportunity for anyone to submit a method for inclusion in NEMI as long as it is published and properly cited. Methods submitted undergo review by scientists and practitioners from the Methods and Data Comparability Board before placement in the NEMI database.

NEMI allows search and comparison of information by analyte, chemical abstract service number, source (e.g., agency or organization), media (mostly water methods at this time), performance (e.g., precision, accuracy, detection level), instrumentation, EPA regulatory status, and relative cost. Search methods include a quick/advanced search, general search, regulatory search, and a browse methods search. It is possible to view a list of all methods in the database. Under the general search, the NEMI database can be searched by media, source, method number, instrumentation, or method subcategory. An advanced search can involve method number, source, method name, detection level, bias, precision, spiking level, instrumentation, and relative cost, among other parameters. Users can click on a specific parameter to get a definition, and results can be sorted by specific parameters. A regulatory search for trichloroethane was demonstrated, including the ability to sort the data using various fields. NEMI also provides links to obtain a PDF file for specific methods that are in the public domain or links to originating organizations for methods that are private.

NEMI can assist in picking analytical methods that best meet data quality objectives, and can help users understand what the data quality objectives are and whether the analytical methods meet data quality objectives for your projects. This may also assist in interpreting old data and avoid the need to collect new data.

A version of NEMI-CBR for chemical, biological, and radiological methods is anticipated to be released this summer; because of homeland security issues, this version may not be made available to everyone. NEMI-CBR is a searchable database for methods related to water security and includes additional fields for method rapidity (e.g., hours vs. days), analyte specificity, class specificity, a Methods Advisor to use as a planning tool, and a "what to do" procedure drawn from the EPA *Response Protocol Toolbox for Contaminant Threats*.

The NEMI-CBR Methods Advisor was demonstrated. It is a user-friendly tool to help plan for an incident or for a response, and lists actions for planning and communication strategies, classifying threat warnings, initial threat evaluations, conducting site characterization prior to entry, conducting initial site entry and evaluation, advice on where to collect samples, as well as how to package and ship them, methods and advice for initial sampling and analysis, methods for confirmatory analysis and monitoring, threat management advice for a confirmed incident, public health response advice, and remediation and recovery advice. EPA will decide how widely available this tool and database will be made.

Next steps include the addition of more methods for new technologies from testing by the EPA Test Facility, the Environmental Technology Verification (ETV) Program, etc.; development of field protocols for sample collection; and bringing in methods for other media (e.g., air, soil, tissue). Another future activity that takes much more restructuring is to include green methods (i.e., methods that can reduce waste from analytical techniques); for example, the USGS implemented a green method for analysis of nitrogen using cadmium reduction.

Future funding for NEMI is unsure. The USGS is attempting to develop a Cooperative Research and Development Agreement with the private sector as a mechanism to help keep the database updated and current. There is also the possibility that NEMI may, in the future, be considered an official EPA methods database, but this is not decided yet. NEMI is available at: http://www.nemi.gov.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) the ability to submit additional analytical methods, such as state testing methodologies for water, for inclusion in NEMI; and (2) how older USGS monitoring programs such as the National Water Quality Assessment and the National Stream Quality Accounting Network may support development of the National Water Quality Monitoring Network.

Use of Exchange Network and Data Standards to Improve and Encourage the Exchange of Data

Following opening remarks by Andrew Battin, with OEI, four speakers provided background on a computer-based information exchange network being implemented nationwide; development of a data standard for environmental sampling, analysis, and results; a regional computer-based information exchange network in the Pacific Northwest; and a state-level computer-based information exchange network developed in the State of Washington. An audience question and answer period followed the presentations.

Exchange Network: Background and Status

Andrew Battin, Director of the Information Exchange and Services Division in OEI, discussed the EPA's National Environmental Information Exchange Network, status of state nodes and information flows with various states/industry, and notable data exchange activities. The EPA Exchange Network is an internet- and standards-based method for exchanging environmental information between partners. Key components include data standards, nodes (points of presence for states, tribes, territories), an XML schema (the format of information flowing over the Internet), and a registry for storing these schema. Trading partner agreements are a key component of the Exchange Network—this is basically two parties agreeing to send data on a specified date or frequency in a specified format. There is also a grant program to provide about $20 million/year for 4 years to states, tribes, and territories to construct their portion of the Exchange Network and to perform related activities. To date, 34 states have adopted this system and current plans are to have this adopted by all 50 states and one tribe by the end of 2005. Many state nodes are operational, 12 state nodes are in development, and 4 states have not yet started. Partners will construct nodes over time.

Every partner has a node. The EPA node is called the Central Data Exchange (CDX). This is a critical point of entry into EPA and ensures secure information exchange. An XLM schema/registry is a mechanism for information exchange regardless of database platform used. Through the use of data standards and this XML schema/registry, it is possible to pass information from states to back end databases residing at EPA. This is very powerful way to share information.

Information flows include air, water, hazardous waste, drinking water, and facility information. New exchanges will include hazardous waste shipments, ambient water quality, drinking water quality, and beach monitoring, among others. Some states have multiple flows. The overall goal is to establish all flows from all states and tribes.

CDX is a "super" node for EPA and supports 20 agency data flows with 10 more in development. EPA is also developing Internet-based processes for activities such as filing a Construction Notice of Intent, which previously was a paper process. Information exchange flows for TRI are also in development.

Notable data exchange activities include:

- Pesticide-related illness surveillance, a grant to make information physicians post in California more available
- Hazardous materials, also a grant in California
- Biodiversity, working with State of Delaware to share data on threatened and endangered species
- Watershed models, a grant for the State of Kentucky to exchange information to run their watershed models
- Laboratory drinking water data, use of the pilot laboratory data standard by Maine, New Hampshire, New Jersey, Rhode Island, and Vermont
- Establishing standardized metadata/tools, a research activity between the University of Minnesota and EPA ORD.

The Public Health Information Network developed by the Centers for Disease Control and Prevention (CDC) is an example of another data exchange network in use.

More information on data flows and how to participate may be found at http://www.exchangenetwork.net. This site provides all of the documentation on how to begin the process as well as the grant program.

The Exchange Network is the way EPA and partners will exchange data into the future. The Exchange Network is anticipated to support nonregulatory and regulatory data flow. The challenge is how the science community can leverage the Exchange Network to share information.

The Environmental Sampling, Analysis, and Results Data Standard

Oscar Morales, Director of the Collection Strategies Division in OIC, presented the ESAR data standard and implications to its adoption for network users. This rather unique standard began as a laboratory results data standard and expanded to consider the entire data life cycle—from sample collection through analysis and reporting of results. ESAR is intended to be the standard for common reporting of results across all media. Development efforts began in 2003 and are anticipated to be completed this summer.

Why develop the ESAR? Laboratory results are a core business at EPA, yet there is little consistency between programs and how information is used. Many laboratories are burdened with paperwork requirements and the events of September 11, 2001 highlighted the need to aggregate laboratory information quickly from disparate sources. There is a prominent need to harmonize laboratory data across many sectors such as public health, emergency response, environmental health and effects, and information quality.

The ESAR developmental approach involved four core guiding principles: consensus-based and collaborative, multi-disciplinary teams to ensure inclusion of data common to all environmental sectors, organization based on the flow of the business process to ensure comprehensive coverage, and modular components to be able to pick and choose among components and arrange them to meet the needs of the data flow. As part of the latter concept, modules from other data standards are referenced. In addition, laboratory managers, program analysts, and database developers worked together to construct the standard and ensure it covers the needs of laboratories, can be implemented by information systems, and can create outputs that an analyst needs and can use.

ESAR is a complex standard and involves four teams (core, water, waste, air). Each ESAR Team has a state and EPA co-chair. Harmonization, testing, and consensus-building all required a lot of time. The development team conducted pilot studies to test some of the components and this is new to data standard development processes.

A modular structure was needed because ESAR is so large and comprehensive; existing standards were aligned to the modules. Modular components enable selection and configuration of specific pieces according to the needs of the information flow. This makes standardization more flexible to user needs. In addition, ESAR has a generic translator that applies to all data elements. Development of shared schema components for ESAR modules can function as part of ESAR and makes development of schema replicable, conformant, and much easier.

ESAR consists of three components—a core, ancillary standards, and existing data standards common to all laboratory analysis. ESAR also references existing standards such as facility/site, biological, and chemical.

The core includes those things that exist regardless of specifics associated with monitoring, media, and type of analysis. The core has a hierarchy of standards for any project. There are four major divisions of

core ESAR (project, monitoring location, field activity, and analysis and results) and each contains a series of data elements.

Ancillary standards are small and separate standards used over and over in various pieces of ESAR and can be used outside of the ESAR context. The ancillary standards address how to convey documents and other items in the data flow. For example, an Attached Binary Object is the way objects such as pictures, maps, and documents can be conveyed with the data flow; Bibliographic Reference is the borrowing of an international standard, like DublinCore, to point to where a document can be referenced. Compositing deals with the science of combining samples either physically or mathematically. Date and Time adds time to the approved standard and uses coordinated universal time (based on Greenwich) to eliminate the complexity of time zones and daylight savings time. Other ancillary standards include equipment; measure; methods; sample handling; treatment; and preservation. As an example, the equipment standard describes equipment used and calibration for the equipment.

The ESAR standard is already being piloted to see if it works. Next steps involve public review of ESAR in the summer, and adoption in the Fall of 2005. Standards are never static so activities after adoption will include review of the standard to ensure that radiochemistry can be dealt with, refining the work on wells, and developing and obtaining approval of business rules.

The Pacific Northwest Water Quality Data Exchange

Mitch West, Oregon Department of Environmental Quality, discussed efforts by the States of Oregon, Washington, Idaho, and Alaska as well as EPA Region 10 to provide multi-user access to a comprehensive collection of water quality data for the Pacific Northwest to address water quality for salmon (an issue of high concern) by applying exchange network principles. The goals were to include anyone with data—from large organizations with highly sophisticated data collection efforts to local watershed councils—and to design a data exchange that in the long run could meet EPA needs and eventually would be able to upload data to EPA's Storage and Retrieval (STORET) system to enhance the utility of the largest database in the U.S. for water quality monitoring data. Diverse participants were consulted on water quality needs; for example, water quality scientists were asked what parts of the data collected is needed to use the data and to determine if it is useful.

All four states received grants to implement the National Environmental Information Exchange Network and all four are investing in building the data nodes. There are a number of data standards addressed including the ESAR standard, standards from the Environmental Data Standards Council (a joint state-EPA effort) and standards from the National Water Quality Monitoring Council.

The vision for exchange data flow involves delivery of information and queries using nodes and web services. A network node listens for a question in a prescribed format, puts together an XML that contains the answer, and sends it to the requester. A key feature is that all of the connected databases can be accessed through a single computer station. The Internet ties this all together for the machines. Getting all of the data in one pace is only one part of the work. There are a number of different issues to resolve about what the analyte is called, what units of measure are used, etc.

The process uses a data exchange template that contains specific information in a specific format with a specific meaning. The XML schema is a set of tags that identify the data, makes the data easy to read by a machine, and allows data quality rules to be enforced. For example, if a required field is not provided in the XML, then a parsing error will occur. There is also a flow configuration document that describes exactly how a query needs to be formatted to be serviced and exactly how the answer is going to come back.

A demonstration of the Pacific Northwest Water Quality Exchange was provided. The demonstration site is available at http://deq12.deq.state.or.us/pnwwqx/. There is the ability to select a data supplier and host databases that house data that cannot be put in a node; examples include real estate transaction data from Oregon and some drinking water data from Idaho. A query can take 10 to 15 seconds to run. This is the computer equivalent of calling around for data and checking to see if it is what is wanted. Once results are returned from a query, the user can browse the details. Currently, users can get only 300 lines from a browse. The user can pick an individual project to get details from an XML file provided by the originating organization. The third step is to download results. The download capability delivers a set of data for scientific use. The system currently has some limitations in its ability to deliver large data sets, but it does provide a much larger data set than might normally provided over the Internet and in a more reasonable timeframe.

What has been learned from this experience? We need to ensure broad user participation, build on relevant standards, and reuse available XML schemas. Two-way communication is also needed with other standards development processes such as ESAR. Learning to share data will teach us what to do next. Much of the effort in information sharing involves common codes and standards, and there is still a lot of work to do. Additional partners and data sources are also desired.

In addition, Oregon, Texas, and New Hampshire are participating in a pilot project with the Office of Water to deliver data to STORET. There are many large geographic areas for which there is no water quality data, particularly in Oregon and Texas. If additional data can be delivered to form a single database, a more comprehensive picture of entire U.S. can be developed. This provides a technical solution to deliver data that already exist to a more broadly used database.

National Environmental Information Exchange Network: Leveraging the Infrastructure and Data Standards

Deborah Stewart, with the Washington Department of Ecology, presented a state-level information exchange network to improve data exchange processes in order to improve reporting, address increased expectations of the public to have rapid access to environmental data, and a growing interest in inter-state data exchanges to support issues that cross state boundaries. The initial efforts promoted data exchange between the Washington Department of Ecology and the Washington Department of Health (DOH) and ultimately to EPA via the National Environmental Information Exchange Network.

Efforts began with the common principles of an exchange network. This includes common exchange and access tools; shared services and infrastructure; data standards and shared formats; common business practices, procedures, and software for electronic reporting and data collection; shared strategy for environmental web services; and trading partner agreements on what and how to trade. Approved data standards, such as those from the Environmental Data Standards Council, are needed before building any new enterprise data application. Standards and protocols are important to facilitating data exchange.

The State of Washington used EPA grant funding to develop a Facility/Site Identification system. This Agency-wide system was populated with over 45,000 facilities within the State of Washington. The National Environmental Information Exchange Network web site provided information on the XML schema and data exchange templates using data standards from the Environmental Data Standards Council. The State of Washington leveraged this work to accelerate their Exchange Network development activities and became the first state the in nation to initiate true data exchange with EPA using facility site data.

Other data flows that the Washington Department of Ecology is working on or has already implemented, include the following:

- Pacific Northwest water quality data (state-to-state)
- Fish tissue data (agency-to-agency)
- Hazardous waste shipment data (state-to-state)
- Resource Conservation and Recovery Act (RCRA) waste handler data (state to EPA)
- Natural Heritage Biodiversity Data (state to state)
- Air quality data (state to EPA).

This type of data exchange takes time and requires subject matter experts.

Washington DOH approached the Department of Ecology to conduct additional monitoring and provide fish tissue data to them via the Internet. Fish tissue data was already being collected by the Department of Ecology and these data were already being published on the Internet in a standardized format and in accordance with specific standards on an exchange network infrastructure. The Department of Ecology collected the additional fish tissue data and added it to their existing environmental information management system which is accessible via the Pacific Northwest Water Quality Data Exchange. This enabled the Department of Ecology to leverage information published for multiple purposes and provide it easily to the DOH. The Department of Ecology provided DOH a template for web services to make information available to them at any time. This effort was completed in a few weeks because the network node, data standards, and technology were already in place.

A demonstration of this system showed how a query results in a list of studies conducted by the Department of Ecology on a specific region. The data provider for the study is contacted via the Internet, and the data are pulled back into a specified format in real time for display on the screen. Additional drill downs enable acquisition of detailed data for a specific study as well as specific analytical data for specific dates. This is all conducted in real time with completely dynamic access.

Another example involves the use of Chemical Identification Data Standards. The Department of Ecology's environmental information management system contains all collected water quality data. A demonstration showed how the user can drill down through the information to the parameter level (in this case, lead). Using the chemical abstract service number, the user is able to link directly to the EPA Substance Registry System; this bypasses the "front door" and goes directly to the specific data of interest. This could not be done without the common link between two the information systems.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) additional efforts needed, such as additional web services, to be able to use publicly accessible water quality data in models; (2) a current challenge grant received by Kentucky to look at data that can be exchanged and placed into watershed models; (3) an EPA Region 10 web-based tool for data exchange that includes mapping capability and will provide "one stop shopping" for regional data once the access can be brought outside the EPA firewall; (4) how most of the National Environmental Information Exchange Network node development work is occurring at the state level and how universities interested in building a node must work with their state to do this; (5) specifications on how to be a consumer or provider of web services for the National Environmental Information Exchange Network can be found on the exchange network web site; (6) how data quality can be controlled through the use of data standards put in place as part of an exchange network before data are entered; (7) how exchanging data often degrades rather than improves data quality but data flow itself does not change the quality of data; (8) the use of data exchange agreements to establish acceptable data quality levels; and (9) how combining two data sets (such as fish data and birth defect data) is not yet part of the data exchange process.

Anatomy of an Indicator

Following opening remarks by Heather Case, with OEI, four speakers addressed the complexity of indicators, the use of the AQI as an indicator, applications of the AQI on a local level, and the challenges and opportunities for scaling indicators. An audience question and answer period followed the presentations.

Anatomy of an Indicator

Denice Shaw, with ORD, discussed indices and scaling. EPA has been involved with indicators for some time. Initial activities focused on the science needed to develop an indicator and in this process EPA found that indicators are subject to tremendously dynamic discussions about the appropriate level of their use in management and whether the science aspect is more important or less important. In the areas on audience, scope, and scale, issues have arisen as to whether indicators should be broader or narrower and whether there should be more or fewer indicators. There are many components and perspectives, and these involve much discussion until consensus is achieved.

An index or indices summarize complex realities—a collection of one or more indicators that may be compiled, interpreted, and other information added. An index represents an integration of information from a variety of sources and involves a set of aggregate or weighted parameters or indicators. Indicators convey clear and simple messages about what is happening in the environment.

Much dynamic discussion has occurred within EPA regarding environmental indicators in developing the *Report on the Environment*. Scale is a particular issue of interest to see whether what is already done can be applied to other geographic areas, cities, or regions. While EPA is reporting on national indicators, the public is also interested in what is happening at the regional, state, community, and back yard levels. Thus, there are a host of expectations that EPA wants to meet, but there are challenges in how to approach and visualize scale given that there are many kinds of scaling (e.g., spatial, temporal, thematic). This is a big driver in where EPA is going in this area.

Indicators offer an opportunity to summarize complex information. In developing indicators, many have suggested that the most important ones be identified so that there are, for example, 70 rather than 100 indicators. This is a real strategic issue as work continues on the *Report on the Environment*—how to identify opportunities to use indices/indicators and how to use them appropriately. For example, how to use new technologies and analytical data to work with the information we have in order to present information at multiple scales and to be much more informative.

The Air Quality Index: A Simple and Effective Indicator

Richard Wayland, with the Office of Air Quality Planning and Standards (OAQPS), discussed the evolution of the AQI over the last 20 years into a forecast tool and an indicator of public health impacts enabling individuals to take specific protective actions. Before 1976, state and local governments had their own systems—55 cities used 14 different indices and they each had different cautionary messages. In 1976, the CAA required EPA to establish a national AQI. EPA developed the Pollutant Standards Index (PSI) that linked air quality concentrations to health-based national air quality standards for five major pollutants: ground-level ozone, PM, carbon monoxide, sulfur dioxide, and nitrogen dioxide; there was standardized reporting for all pollutants. The PSI was used for 22 years.

In 1998, EPA revised the air quality standards for ozone and PM, and decided to change the PSI to emphasize the link between air quality concentrations and health risks and to tie in more cautionary health words to make the index more useful. As a result, the PSI became the AQI. In developing the AQI, EPA

conducted focal groups in major cities across the country and obtained input from state and local experts as well as the public.

The AQI consists of six simple, color-coded categories and has a health statement for each category. The index shows the relationship between the calculated values and health, not the regulatory standard. This is strictly to indicate air quality for public health. One of the most important things that EPA did was to put color into the index.

The AQI is calculated using a formula. The ozone value is based on an 8-hour average and the PM2.5 value is based on a 24-hour average. The formula converts the concentration information to an index. This is useful because the public does not understand concentrations; the index value can be tied back to concentrations of specific pollutants and can be tied to health effects. The AQI must be reported at the city level; therefore, the calculations are performed based on MSA conditions.

Originally, the AQI was "yesterday's news" because it averaged previous data. As such, it served as an indicator of long-term trends in air quality on an historical basis (for example, to determine how many Code Red days occurred in the last year) and therefore provided some indication of past health risks. What the AQI did not provide was an indication of current or potential air quality levels, or violation of standards such as the National Ambient Air Quality Standards (NAAQS), which have triggers involving 4 year averages rather than the 8-hour data for health impacts.

The AQI is now able to be used in a real-time/forecast mode to serve as an indicator of current hour and future day(s) air quality levels. Calculations are still performed at the MSA level and estimates can be developed for areas (e.g., rural areas) where no air quality monitors are present. Thus, when the public receives a forecast AQI for the next day, individuals can take action to reduce their contribution to air pollution and improve the air quality where they live. However, the forecast AQI does not tell whether anyone took any pollution-reducing measures nor does it address regulatory issues.

For the forecast AQI, real-time data are collected from 1,500 monitors and AQI forecasts are developed for 300 cities. To demonstrate how this data can be used, an animation of changes in ozone AQI data over time was presented; this was developed from air quality data that were converted to the AQI then mapped using the color codes for the index. This illustrated how air quality changes throughout the day as well as what maximum levels occurred in specific geographic areas. A similar animation was prepared for PM2.5, but this was done on a point basis because there are not enough monitors to achieve the same level of interpretation as was possible for ozone.

There are several challenges for the real-time AQI. One is the time lag encountered in conducting an 8-hour average for ozone and a 24-hour average for PM2.5. For ozone, a surrogate approach was developed to look at the relationship between the 1-hour peak in a day and how it relates to the 8-hour peak for the day. From this analysis, an algorithm was developed to relate those peak concentrations and the algorithm was applied on an hourly basis throughout the day; this provided a more relevant picture of what the index is for that hour. For PM2.5, with a much greater lag time given the 24-hour average, the 12 hour mid-point of the 24-hour time period was taken and the last 4 hours of the time period were more heavily weighted. This combined a little bit of real-time data with a little bit of forecasting. These approaches err on being conservative for health protection.

In a 2002 "green gauge poll" by Roper, 52 percent had heard of Code Orange or Code Red. Of those, 46 percent had reduced their exposure to air pollution and 37 percent took actions to reduce air pollution. Thus, the AQI is an index that leads to an action. As another example, the University of California, Los Angeles, conducted a study in Southern California and found a 4 to 7 percent reduction in pediatric

hospital admissions for asthma that was attributable to air advisories; researchers found that children took their inhalers to school or took other protective actions.

Future activities include a National Activity Survey to evaluate the effectiveness of AQI alerts on public behavior to see if people take action in response to the AQI. An EnviroFlash E-Alert system is being put into place and EPA is working with state and local governments to provide this service. Other needs include expansion of the role of AQI in air quality toxics, focused on short-term health effects and how to address long-term effects; improvement in geographic coverage of monitoring systems and therefore the AQI; use of satellite data to relay air quality information and tie that information to an index; and deployment of mobile monitors for wildfire events and other emergencies.

Since 1976, the AQI has gone from a tool to an indicator and predictor, and works as a result of its simplicity, colors, and uniformity. The AQI is a very good indicator for historical, current, and future air quality levels and health risks. The AQI alone does not indicate specific health impacts, but is an indicator for the potential for those impacts to occur. The AQI is not the only air quality indicator but it is the most widely understood and accepted by the public—it is the one the public understands the most and that alone is an indicator.

Using the Air Quality Index on a Local Level

Randy Mosier, with the Maryland Department of the Environment, presented initiatives at the regional level to use air quality information to elicit action to protect health and reduce air pollution. Clean Air Partners is a collaboration between the Baltimore and Washington, DC, regions including Virginia and western Maryland. This public-private partnership was chartered by the Metropolitan Washington Council of Governments and the Baltimore Metropolitan Council to promote easy and effective voluntary actions that individuals can take to reduce the production of and exposure to air pollution. Western Maryland has recently been added to the region of interest because monitors have now been placed in that region. There are many areas without air quality monitoring in the State of Maryland; a challenge to adding monitors is the perception that bad air quality will be found and regulatory actions, such as preparing an implementation plan, will be required as a result of the monitoring.

In 1993, Clean Air Partners began forecasting air quality for the region and in 1994 began color coding an ozone map for forecasting in Baltimore. In 1996, the Ozone Action Days program began; this program promoted taking voluntary action on days that were designated Code Red. Several mapping projects were piloted using monitoring data collected from Maryland, Southern Pennsylvania, Washington, DC, and Northern Virginia; Clean Air Partners took this tool to the television stations hoping they would show this information and there was some success in this area. In 2002, PM was added to the forecasting to reflect that there are multiple pollutants and the program goal is how to project overall air quality. With this change, the name of the Ozone Action Days program was changed to Air Quality Action Days.

The Air Quality Action Days program is intended to let people know when the air quality will be bad. The message on air quality is communicated daily through faxes, emails, etc. to specific organizations who are asked to also spread the word to others and the media. This is providing good assistance in disseminating the information and in getting people to take voluntary actions.

This year, extended range forecasting began for ozone and PM. This takes the forecast 3 days into future and helps the partners prepare and set pollution-reducing actions in place, such as carpools, restricting refueling to the morning, curtailing mowing, etc.; it is difficult to set up such actions if the forecast comes out late afternoon on the prior day. The extended range forecasts are applied to action guides sent to businesses and the action guides offer ideas on how to protect health and polluting activities that they can curtail. Much of this information is provided by EPA and Clean Air Partners tailors this information to

this particular region. The extended range forecast is a very customizable tool and uses the same framework of colors as the AQI.

Efforts are constantly underway to determine how to reach the broadest audience, how to get monitoring data to EPA, and how to disseminate information through products as described above. One example is Air-Watch (at http://www.Air-Watch.net), which reports real-time and forecasted information for the Baltimore-Washington region. The web site includes images from haze cameras to show what unhealthy air looks like and provides real-time information presented in air quality index maps updated with hourly averages to show how ozone levels increase during the day—ozone may begin as green on the map, then turn yellow then orange as the day progresses. Users also can check data for monitors in specific areas. As there is more access to real-time monitors, PM may be demonstrated to be a problem in the morning and afternoon, while ozone seems to be a problem in the afternoon.

Historical information is always important; an example is how many Code Red days occurred in the last month. This information is being organized and put in calendar format, including peak information; this helps provide an assessment of how bad the air quality was in the region at any time.

A "call in" number is provided—both local and toll free ("1-800"). Traditionally, the telephone has been the format for communicating air quality information and forecasts, and this has been found to be useful. This process is now being automated to collect and vocalize the information. A video clip from Baltimore Channel 13 demonstrated the ability to call in and check air quality, and an interview on the clip demonstrated how an asthmatic's condition could be controlled by controlling exposure. This shows that people do use this information in whatever format we can get it out—not everyone has a computer or can take advantage of online information.

Another product is AirAlert, which is similar to EnviroFlash. Traditionally, communication of alerts was by fax or email, and this was made accessible by anybody (e.g., business, individual). AirAlert takes this further in this region, and anyone can sign up to receive instant notification of air quality changes that cross into a specific color coded area (e.g., to orange, to red, etc.); an email or text page can be sent. Clean Air Partners is also working closely with meteorologists to communicate air quality information and many are integrating this information into their news segments. Because this region has had two summers with very good air quality, it is difficult to determine the success of this effort.

Index Development and Scaling – Challenges and Opportunities

Jay Messer, Senior Science Advisor with the National Center for Environmental Assessment (NCEA), discussed the multiple perspectives in viewing an indicator and the challenges of scaling indicators from both the scientific and information standpoint. Indicators are meant to convey complex information simply and objectively, and are used to make a large quantity of complicated data simple in order to convey it to different audiences that do not have time to go through all of the complex data. Scale involves the physical dimensions of an observation in time and space. Grain size represents the smallest dimensions in an observation set; for indicators, this is the smallest unit to be discussed even if there are smaller measures that were combined into averages. Extent is the total area or time over which observations are made; this can range from a national average over a year down to measurements at the backyard level over a period of an hour. There is much discussion of what is the right scale, and it is possible that there is no one right scale or that many may be appropriate.

There are two particular scale issues that EPA has been addressing. One issue is reducing dimensionality—making many pieces one. Examples include the AQI and previous presentations illustrated the complexities involved with that indicator. Other examples include indices of benthic

invertebrates, streams, and estuaries or an indicator that adds together "tons of pollutants" when there are many different kinds of pollutants.

The second issue is scaling—national (e.g., my country) or very localized (e.g., my backyard). Three examples of scaling challenges were presented. The first involves the AQI and an analysis of trends in the percentage of MSA days where the AQI was greater than 100 (i.e., air is unhealthy for sensitive populations). If any monitoring station within an MSA is greater than 100, this equals 1 day; the number of days of measurement can be added up and the number of the days greater than 100 can be added up and this information can be used to derive a percentage. There are about 80 MSAs where there is a complete historical record from 1990 to 2002. Using this data to generate a national average, about 4 percent of the MSA days have an AQI greater than 100. A graph presented the national average information as well as data for each EPA region; EPA Region 9 was well above all of the other regions and the national average, Region 3 was around 6 percent, and the rest of the EPA Regions were lower than the national average. This translates into different risk for an individual based on where they live with regard to this parameter. However, because some EPA Regions have only one or two MSAs (since monitoring tends to occur where there are problems), the data for such regions is really based on information from one or two cities. This is a scaling issue.

A second example involves evaluation of the population served by water supplies that have no health-based violations. A water supply system can have a violation of a regulatory limit (such as the coliform number) or a treatment technique (for contaminants that cannot be measured effectively on a day-to-day basis). Findings of this evaluation indicated that, at the national level, 94 percent of people are served by municipal water supply systems that have no health violations. Graphs of the data for each EPA Region showed that seven regions had a higher percentage than the national average, and that several regions were below the national average. Focusing on a single region, EPA Region 2, there was a large dip in 2003 that appeared to indicate a significant decrease in the population receiving water from suppliers with no health-based violations. There are four large treatment facilities in Region 2, one of which serves 2 percent of the U.S. population. In this case, one facility had a treatment technique violation; correcting the data for the violation at this plant accounted for most of the dip. Again, this is a scaling issue affecting data interpretation.

A third example involves the TRI. In looking at trends since about 1988 for total TRI releases to all media, there appears to be a tremendous reduction in the amounts released to air land, water, etc., with particularly large reductions seen in releases to air. When the same data are examined at a different quantity scale, a big increase in waste solidification is seen. The data also showed changes as a result of a court ruling that overburden was not a waste. Also, a presentation of bar charts showing trends in TRI releases to land showed how the trend data changed when the top 10 facilities were removed and when the top 100 facilities were removed. These changes resulted in dramatic decreases and caused the national trend to be that of decrease.

Scale and hierarchy are not the same thing, but they are related. At a highest hierarchical level there are boundary conditions that constrain at the focal level about which nothing can be done (e.g., weather). If a focal level is thought of as something like budgets or appropriations in a government process, there are statutes/regulations that constrain and there are operations (e.g., day-to-day, how manage waste in company, whether go outdoors or not). If these are considered to be related in time or space scales, a potential solution is to consider who might be informed by the indicator and there might be an appropriate time/space scale for each.

Potential future directions include the exploration of toxicity-weighted emissions (e.g., small amounts of toxic materials versus large amounts of less toxic materials) and analysis of scale relevance, the effects of

very large systems on national averages, issues of ecological comparability (such as benthic indices), and the statistical aspects of indicators in order to get the right information to the right audience.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) comparing past forecasts in the Baltimore-Washington region with actual data to tune predictions and the high level of accuracy being seen in the extended forecasts; (2) concerns about economic impacts of inaccurately predicting Code Red days (i.e., "crying wolf") and that there have only been three such incidents to date under the Clean Air Partners efforts; (3) incentives for installing air quality monitors with an example offered where EPA money was provided to a state to do real-time monitoring for PM2.5 that does not comply with EPA method requirements for regulatory monitoring and therefore the data cannot be used for regulatory compliance determinations; (4) concerns at the state level that if a monitor shows unhealthy air, even in nonregulatory monitoring, and EPA will require the area to be more closely examined; (5) a new strategy being developed between EPA and the states to determine where to best place air quality monitors from a research, regulatory, and health monitoring standpoint; (6) the tendency to place monitors based on population given the regulatory goal of providing public health protection; (7) the finding from the initial *Report on the Environment* efforts that indicators are used by many people for different reasons (e.g., policymakers to ask where to go next, the public to identify measures to protect themselves) and how the next iteration on the public portion of the *Report on the Environment* will focus on an audience that wants to learn more about how our nation is doing and understanding what the needs are; (8) the goal of using indicators to shape the next version of EPA's Strategic Plan and the effort involved in learning the different audiences and the uses of indicators in order to develop products (e.g., tools, web sites, reports) to meet the specific needs; (9) the potential to find higher incidents of exceedance of air quality standards when additional monitoring is added; (10) how monitoring today is based on population size/location 20 to 30 years ago and how rural areas are becoming urban yet have no air monitoring because they are not part of an MSA; (11) relevancy of scale when the public asks what something, such as the *Report on the Environment*, means to them; and (12) how the hierarchy theory is a possible bridge between local scale and national reporting, which is of interest in Europe as well, and how to develop understanding of different indicators at different scale, which is an activity in preparing for the 2006 *Report on the Environment*.

Language and Metadata Management International Collaborative Projects

Following opening remarks by Larry Fitzwater, with OEI, three speakers addressed concept management and data standards for metadata, the international ecoinformatics initiative to construct a common terminology, and European efforts to develop an exchange network. An audience question and answer period followed the presentations.

Metadata Management – Moving into Concept Management

Larry Fitzwater, with the Data Standards Branch in the OIC, discussed the data element and data set aspects of metadata. Metadata is information about data, varies in complexity, and has many levels. Metadata to one person is different than metadata to another. In one case, it can be the physical location on a disk where the data bits go or, in another case, it can be the agency from which the data come.

Metadata are important to better manage data. Finding information without metadata requires that assumptions be made, and these assumptions are not always accurate. EPA has a registry for metadata and the intent is to collect information about EPA data elements and data sets in a standard manner so that anyone who wants to use EPA data knows what EPA thinks is important about that data.

EPA built the registry on ISO standards, of which ISO 11179 Parts 1 through 6 are particularly critical. The 11179 standard was developed originally for data elements and has been expanded to other data items. Part 3 is the important part and defines a metamodel, which is a description of all of the things to be collected (300 or so); in the EPA Metadata Registry, there is the capability to collect all of the items defined in Part 3, but not all are collected as EPA does not want to expend resources to record or track what is not needed. The next important part is Part 6, which talks about how to build a registry to put the information from Part 3 into a comprehensible form. Part 1 is an overview of the framework on how all of this goes together and Part 4 is definitions.

Part 5 is how to name things and how to identify them. Many would like data to be managed based on names. However, there is never a single concept that does not have more than one way of being expressed and there is never a single term that does not have more than one meaning. Naming is important, but there is also a need to have identifiers, to attach multiple definitions in different contexts, and to attach multiple names in different contexts. This process makes a piece of data unique, like a social security number distinguishes between different people with the same name.

Part 2 of the standard addresses how to organize data into different structures, which is critically important. Data do not come singularly; data come as part of a pack so to speak. For example, a street name is part of an address block containing several other items of information. Thus, when you get one piece of data, you know that others may be connected.

An administered item is what someone will collect information about. This includes administration and identification, classification, and naming/definition. Administration/identification goes into great depth on the types of information that need to be collected—who owns it, where did it come from, what does it mean, who to contact if want to know more, when did it become effective, has it been superseded, what else has it been connected to, etc.

Data elements include a data element concept, conceptual domain, the data element itself, and value domain. The idea is that every data item has an associated concept of what it involves. For example, for "name," the data element might be employee name and the value domain is the list of employee names that form the possible choices for the data element. When considering data elements, questions arise as to whether different data elements have the same concept and the same set of possible values. The purpose of registries is to provide a single place to put all of these things together.

Concept management is different from data management and it is not about how write it or see it on the screen. *Roget's Thesaurus* is an example of concept management, where things (words) are grouped by characteristics.

The semantic web is about finding not understanding information and is intended to be used by machines to find what the user requests. As such, the semantic web does not really address metadata management because it is about finding data on the web that someone else collected and as a result, does not address why the information was collected or other things that the originator knows about; without the metadata, the data can be misused. As a result, the semantic web is still a developing concept. Things to do to prepare for future use of the semantic web involve knowing how to find information based on concepts and developing registries that contain concepts.

Concept management is necessary for data management, metadata management, portal management, and content management. The last is particularly difficult because it spans databases, semi-structured data (like an email, which contains "to", "from", "subject", and a block of text), and unstructured data (like documents). Standards exist for unstructured data, such as DublinCore (developed by the library system)

that addresses such elements as title, author, and date, and standards exist for data groups and data sets that are particularly applicable for geospatial applications. All of these have capability of attaching to key words or concepts.

Content management is necessary to obtain results from databases or documents, or to speak to someone about a specific topic. Terminology and terminology management is a necessary underlying part of content management.

Ecoterm: An International Initiative for Environmental Terminology Sharing

Gail Hodge, with Information International Associates, Inc., discussed the international ecoinformatics initiative and challenges associated with developing a common terminology to use when talking about data and dealing with metadata. Where terminology meets metadata is in completing the content that is in the metadata elements. For example, the DublinCore ISO standard contains 15 high-level elements that are used to describe web-based resources and now is also being used for things like data sets, books, and videos. Within that particular element set there are many data elements (such as subject) that can be controlled by pick lists. Using a pick list, a standard set of key words, or something as elaborate as a thesaurus, it is possible to look at how to fill the metadata elements with a more controlled terminology. This gets into the conceptual domain and dealing with the specifics of a format and set of valid values to fill the data element concept.

Within knowledge organization systems are structures to organize concepts and terms. Examples include key word lists, thesauri, and ontologies, which are more complex because they take related relationships that a thesaurus does not handle very well (e.g., cause and effect) and expands that to make it more precise. These are traditional methods for controlling terminology and can be used to determine the valid or domain values for a data element by taking advantage of years of work that has already gone into some of the classic terminologies and terminology structures from the science domains. These are intellectual assets already developed by many science organizations, and each organization has built these thesauri over 30 years or more and for specific instances. These can be very helpful if they are made interoperable for data sharing and are moved into the semantic web concepts discussed in an earlier presentation.

The ecoinformatics initiative is looking at how to take advantage of these terminology systems. This initiative developed out of discussions with Ecoinformatics International and is a cooperative effort that began in 2003 to share terminology and meaning in support of data sharing with work being done in Europe and the U.S. The Network Knowledge Organization Systems Working Group has held several meetings, with an international focus, to determine how to prepare these classical terminology structures for the semantic web.

A charter has been developed that will change over time with a goal to look at how to make environmental terminologies more interoperable and generally more useful. Another goal is to look at standards for terminology and how to provide integration, meaning, and definitions across heterogeneous data and information systems so users can better understand data as well as similarities and differences among terms and data.

The United National Environment Program hosted Ecoterm I in Geneva in April 2004. There were more than 30 participants, including terminology developers, lexicographers, information technology professionals looking at semantic web concepts, and people interested in multi-lingual aspects of terminology. Many organizations participated including EPA, USGS, the European Environment Agency, United Nations agencies, scientific organizations, and vendors. A survey was conducted in advance of the meeting and the information compiled into handouts that identified overlapping interest and ongoing projects. During this meeting, participants exchanged data on terminologies; looked at

existing networking systems, particularly work done by the United Nations in this area and looked at development of use cases and user needs (e.g., why someone would want to interoperate thesauri and other vocabularies); and relevant technologies and standards that would help to interoperate terminology systems.

A second meeting, Ecoterm II, was held in Berlin in April 2005. This involved more than 20 participants from nine countries and three international organizations. Activities involved updates on the major terminologies and technology projects underway; working on technical activities identified in first meeting; collecting additional information about environmental terminology resources; and review of relevant terminology standards. Efforts also involved work on a taxonomy of knowledge organization systems to provide better definitions of what constitutes a thesaurus, classification scheme, and ontology; this involves examination of metadata on taxonomy resources to help identify what these particular systems are like and, more importantly, to look at how they relate to one another, their behaviors, and what could put into computerized system. Much of the work in the past year has been driven by the semantic web and semantic web concepts. Investigation of technologies for interoperation found that many were starting to implement the Simple Knowledge Organization System core—a vocabulary for expressing terminology systems in RDF in descriptive resource framework, the standard for development of semantic web—and they have developed tools/toolkits for taking classic thesaurus hierarchical structures and transferring them into an RDF structure. An outcome of the Ecoterm II meeting is the desire to prepare an inventory of web services to enable better sharing and to avoid duplicating efforts.

Another topic of the 2005 meeting involved intersections with the ISO 11179 enhancements, in particular the Extent of Metadata Registries project. This involves the development of use cases including scenarios that address, in more detail, why an organization wants to do this, what are the needs of a knowledge organization, and who are the audiences for interoperable systems besides computers (i.e., who would such a computer system help).

Between the two meetings some web services were prototyped. For example, the U.S. National Agricultural Library developed a prototype terminology web service; an example is a scenario where someone comes into their thesaurus and selects a term and its synonym (e.g., corn/maize), and the systems transfers to the General Multilingual Environmental Thesaurus (GEMET) and searches to obtain the foreign language equivalents. With this approach, sending the combined search strategy out on the Internet (e.g., via Google), the user would also obtain foreign language materials on the selected topic.

Ecoterm information is available from Ecoinformatics web site (http://ecoinfo.eionet.eu.int), and there is an email reflector that EPA posts. There is also great interest in forming liaisons with other groups. Benefits for participants include access to shared technology development including agency-specific terminology systems such as GEMET (part of EPA terminology reference system) and the National Biological Information Infrastructure (NBII) Biocomplexity Thesaurus which is at a more granular level than GEMET; the ability to have more impact on standards development; opportunities to hear about use cases and influence developers to modify approaches to meet our needs; and to create an environment for sharing terminologies and supporting other international initiatives.

Environmental Data Exchange and Semantic Management in Europe's EIONET – Open Standards, Web Technologies, and Open Software

David Stanners, with the European Environment Agency (EEA), discussed European efforts to develop an environmental data exchange (Eionet and Reportnet) and approaches to conducting data exchange and semantic management to support EU reporting requirements and activities. Progress in this area has come out of cooperative activities within Europe and with the U.S. and the United Nations.

The EEA is an institution of the EU, but its membership includes Mediterranean and Commonwealth of Independent States countries as well. The EEA is a tool for EU policy and for countries to collect and make available information to the public and to support the policy process.

Each member state is collecting and organizing environmental information. Eionet is a network that helps to bring all of this information together and encourages exchange and learning. Eionet includes EEA and European Topic Centers (e.g., air, biodiversity), and these work together with National Focal Points to have proper data exchange across more than 800 organizations.

Reportnet resides within Eionet and is the concept by which the exchange is organized and all information flows to prepare a "state of environment" report on European level and to facilitate reporting to the legislative level against directives and to the EEA for reporting assessment activities. There is a network directory of who is involved, a content registry of what is inside, a set of reporting obligations (i.e., established "by law"), a data dictionary describing what is required for reporting, data exchange modules that facilitate exchange, and national and European repositories. The environmental data exchange uses integrated technology tools and business processes, and uses several metadata standards, primarily ISO 11179. There is a reporting obligations database to help users find what has to be reported, when, to whom, why, by whom, and what are the guidelines; this has to be updated to keep current with changing requirements. A data dictionary helps users find and access data definitions, guidelines, and templates. Some modules have been implemented and some are in development.

A simplified diagram of the overall schema was provided to illustrate how Reportnet and Eionet work. The first level is where reporting obligations are defined and the data dictionary reside. At the national level are the national databases, national data dictionaries, guidelines for data exchange module, and repositories that are then loaded according to the guidelines. The national data are merged at the European level—involving 31 countries and 25 languages—to form European data sets and a European data repository. In addition, there is a quality control loop that includes qualitative validation using various algorithms and models used to test and to quality assure information.

This demonstrates that in working with more than 25 countries, shared technology is useful, easy, and implementable, and use of industry standards is necessary and accepted by all. In addition, integrating systems using web services is one of the most successful ways of exchanging information. Other conclusions from this effort include:

- Good experiences with open source tools
- Adoption of EEA standards and approaches by individual countries and outside institutions is resulting in a convergence of approaches
- XML is useful as underlying data format, but requires vast conversion routines which must be offered to users in order for there to be proper integration of the work.

The data dictionary is a core element of the data exchange as it is a central place that provides detailed definitions of data to be delivered on a reporting obligation; the standards used in this effort are the direct result of collaboration with EPA. The data dictionary defines exactly what is to be delivered and under what obligations, a structure of data sets to be supplied including data element definitions, templates, and common code sets and data elements. Lessons learned from the data dictionary work include:

- Open source software is essential (available online at http://eionet.eu.int/software), and can be modified by the user while still enabling data exchange

- How it is helpful to have the ISO standard harmonize between and across thematic areas (e.g., water, biodiversity, air quality), yet some modifications must be made for different communities (i.e., can only standardize to a certain level)

- The need to expand awareness of the need to utilize metadata standard 11179 and its applications within the countries to ensure harmonization and improvement of the exchange experience.

Lastly, semantic management activities began in 1991. Catalogs already existed in various languages and were turned into the GEMET thesaurus in 1996. This has been expanded to 5,300 terms in 21 languages, and is a significant source of information. At this time, the definitions themselves are currently only in five languages and include only the concepts. The amount of concept confusion is extraordinary; for example, the concept "soil" gets into land ownership in Italy and France, while in England it means the material itself. Thus, it is necessary to tease out these different meanings. There are over 400 institutions in Europe and elsewhere that are using the GEMET thesaurus and this has turned into an international collaboration. GEMET is fully available at http://www.eionet.eu.int/gemet. While many believe the primary users are translators, this thesaurus can be used for searches and metadata as well. As development efforts continue, it is necessary to be aware of multiple uses and to make it available to a broad range of users such as off-line users, web applications, and customized interfaces being considered; this requires ongoing definition and translation of terms. Efforts are also underway to see how GEMET can be integrated into a wikipedia structure to support updating and management of the whole system.

There is no overarching funding—all of the activities are based on voluntary efforts and are being conducted on a needs basis.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) ecoinformatics initiative focus on environmental terminologies and technologies to manage those terminologies; (2) the challenges of using antiquated management tool to, for example, export existing thesauri in RDF; (3) two structures being considered to provide searchable integration across information categories for updates with the final outcome anticipated to be a hybrid of the two; (4) the possible use of wikipedia to provide a true collaborative environment to develop and maintain a thesauri; (5) who would be responsible for updating or making changes to a thesaurus, including a work flow that allows contributions and some type of 'vetting' process; (6) how terminology updates are a business problem rather than a technology problem and that solutions will be situation specific; (7) how the DublinCore standard is used in Eionet for unstructured data, and the importance of the guideline document and data dictionary that underpins the data exchange; (8) how databases involve oversimplification of information in order to get the data to the place where it can be used, which is not a new problem, and how the semantic web, where searches can be done based on concepts, may help address this—there is no substitute yet for someone reading the information and making sense of it; (9) there is an overarching schema for Eionet, which may have to be modified during the long process of integration with the greatest priority placed on air quality and climate change, water having middle priority, and biodiversity issues still in progress; (10) a test bed being run by EEA and the U.S. on air quality and health information to look at requirements for commonalities in semantics and metadata in order to pull out key action information and the hope that such an approach can be applied to other areas such as water and biodiversity; (11) EPA consideration of a metadata policy to encourage data originators to provide and update their metadata, the need for tools and systems to obtain metadata when the original data are created to minimize time spent on this activity, and how to create those streams of metadata; (12) how standards and tools allow data collection to happen and the need to educate researchers on the value of metadata and the systems to collect it drawing on an example from the NBII whereby funding is provided

for metadata training and review, including research data, web sites, and information coming in through the NBII portal; (13) the European perspective of needing to move to automation to help move metadata collection forward and how awareness raising is needed as many in charge of funding resources do not understand metadata, its value, and the need for high quality metadata to support policymaking; and (14) increased involvement of CDC in the ecoinformatics area, with examples including the development of an environmental public health tracking network, development of a metadata template for cataloging, and investment in software and tools for automated generation of data elements from the common information held in human health and chronic disease registries.

Enterprise Architecture in Action: Analysis and Tools for Decisionmaking in the Regions and States

Following opening remarks by Megan Quinn, with OEI, four speakers addressed the EPA enterprise architecture, the EPA Science Portal, WRApp, and the Council for Regulatory Environmental Modeling's pilot water quality model selection tool. An audience question and answer period followed the presentations.

EPA Enterprise Architecture

John Sullivan, with OEI, and Brenda Young, with ORD, discussed the role of enterprise architecture as a way to connect all of the activities being conducted by EPA to more efficiently leverage each other's work. Everything EPA is doing is trying to solve a strategic mission or business aspect problem, using some information, or using an application or database, so the challenges involve science as well as technology. The purpose of enterprise architecture is a classification scheme to help think about this complexity and to put it into a mental framework.

A slide showed typical architecture layers in a pyramidal structure, with each layer building on those beneath. First (at the top) is the strategic layer and this begins with EPA's Strategic Plan—What do we do? What are the business services? What data are needed? This requires looking at all of the projects and science at EPA to determine what each is supporting, how a solution can meet some other goal or help something else within EPA, how to measure performance, and how investment in funding and LOE actually improve the environment. It is a challenge to draw all the relationships and connections because EPA is complex and there is a need to share information with many organizations, internally and externally.

Next is the business layer and this is about solving a business problem. This considers such aspects as who to involve, whether other projects are supporting a specific project or others in the same way, whether there are things in the underlying work that suggest a better way of doing business within EPA, what is driving a project (e.g., is there a business problem we are trying to solve), who is involved, and what are the interconnections we need to accomplish our work.

The data layer considers whether success is based on data quality, where data are coming from, and if the outcome would be different if more or better data were available. It is necessary to balance these considerations because the Agency cannot afford to get perfect data or to get all possible data, and this balance specifically considers the gain in a program with investment made in the data. EPA is both a consumer and a provider of information, so it is important for EPA to understand its relationship with others with regard to data. As an example, EPA will be soon be signing an agreement with the Department of Health and Human Services to lay out EPA's commitment and role on how to support building the health architecture including conceptual input, staff, and money. This layer also considers opportunities to better disseminate information to users in the Agency and dissemination of EPA data to a broader universe of users.

The applications layer considers what technologies are involved in the science at EPA. Research in science provides valuable support to air, water, and land management areas. Key questions include how to apply that research and what is the suite of applications and services to provide within EPA. The role of enterprise architecture is not to curtail or limit the possibilities of the science and tools that are needed, but to identify the responsible suite of capabilities and the infrastructure to support that. This involves a balance of fiscal responsibility, opportunity, and creativity.

The technology layer supports all of the layers described above and is where all of the individual pieces of the architecture come together. This layer involves having the infrastructure capacity to do the type of science that EPA needs. The purpose of the enterprise architecture is to understand and plan the infrastructure capacity needs to do the types of science planned to be conducted at EPA. For future investment, demand must be balanced with the ability to meet that demand.

A diagram was presented that represents efforts to identify the relationships and interconnections within EPA between and among the research- and science-oriented organizations as well as the components involved in science and research. In supporting all of those business functions are a number of ongoing scientific information and quality management functions, high performance computing and geospatial analytical capabilities, collaboration (within the Agency and between the Agency and others), and standard technical solutions. The purpose of this diagram is to understand the core set of services that support EPA's ability to conduct these scientific services and to better understand the science needs of the Agency.

The research and science architecture addresses the research- and science-specific aspects of the enterprise architecture and draws from the EPA enterprise architecture for components such as data integration and modeling tools. Activities underway include defining where we are now, where we want to get to, how we want to get there, and what is needed that we do not already have. The goal is to move toward an interdependent, component-based environment solution.

The Science Portal – An Enterprise Approach to Science and Collaboration

Jacques Kapuscinski, with the Office of Resources Management Administration in ORD, discussed the EPA Science Portal, its vision, and features, and demonstrated how the Science Portal can support the larger enterprise architecture. A slide showed the overall EPA portal, which includes components for environmental and health protection, administration and management, and research science. All of these components support ORD and the EPA Regions when data or models are accessed. The Science Portal links to the research and science architecture discussed in the previous presentation and will be linked closely to the larger EPA enterprise portal.

The research and science architecture is a tool to aid in planning information technology investments and provides a blueprint for product development and mandates such as e-gov initiatives and the President's Management Agenda requiring enterprise architectures. The research and science architecture provides a structure and a way to coordinate/link scientific information management with technology.

The Science Portal and other capabilities such as geospatial analysis are components of the research and science architecture. The Science Portal will provide a suite of tools supporting virtual research, enable users to communicate and download data sets in a shared workspace, allow for customization of what is seen, and support preparation of presentations and documents. Computers are social networks that use data and technology and link people together through information and data; therefore it is necessary to provide the proper context yet allow users to integrate content and data.

The Science Portal includes modeling capability, news feeds, weather, and data. When completed, users will be able to download models and data to be run on applications on computers other than their own and will have access to visualization tools. The Science Portal will be a test bed for interoperability. Scientists will not have to worry about the information technology aspects as those will be done for them. Users will be able to download data, understand metadata, do cross-collaboration, and do more integrated research.

The Science Portal is a tool for scientists and other users inside EPA and is not intended for the public. With the implementation of the Science Portal in Oracle this fall, the data will be downloaded in a consistent format to make it easier to compare data sets and to support many different applications; this presents users with a "common look and feel," which will support collaboration through a single platform. There will also be some very powerful capabilities to quickly authenticate user identification, and to quickly organize the information whether it is PowerPoint presentations, downloading models, etc.

The next steps to developing the Science Portal include stakeholder forums to develop user interest and for developers to understand data needs. The goal is to bring the right tools and resources to the fingertips of scientists, collaborators, and decisionmakers, and to be able to use this as a very powerful communication tool, such as supporting online modeling discussions.

A brief demonstration of the Science Portal was provided to the audience and a request was made for additional participants to sign up for involvement in the test program. There will be demonstrations in ORD laboratories, in EPA Regions, and with EPA programs. A Science Portal Advisory Board has also been created. The goal is to involve a broad mix of personnel from across EPA and to engage them as early as possible to understand user needs and requirements.

A critical component of the Science Portal is the EIMS—a repository of metadata about EPA projects, peer reviewed documents, data sets, models, and documents. The EIMS contains over 42,000 cited publications, 100 models, and 600 data sets; this will be a critical background component for the Science Portal as a virtual library.

Analysis and Tools for Decisionmaking: Collaborating and Coordinating with Regions and States

Ming Chang, with OEI, presented WRApp, which is a gateway to access available tools, data, and decision support systems at the desktop computer level, and will eventually be made available via the Science Portal. WRApp capabilities are customer driven and WRApp will be piloted in EPA Region 5, specifically for water.

The EPA Regions and the states were asked to identify a useful tool to develop, and several needs came up over and over: easier ability to update and access data for analysis, the need for complete and comparable data sets, and the need for appropriate tools/models to help with analysis to answer questions such as the effect of increasing development and land use changes on flooding, water resources, and animals as well as where and how total maximum daily loads (TMDLs) affect us. In evaluating this input, several roles appropriate for OEI were identified:

- Help synthesize and provide tools support and multimedia integrated analysis at multiple scales to enhance environmental decisionmaking at EPA
- Reduce duplication
- Enhance collaboration since many similar activities were found to be underway.

Tools and data will be populated within WRApp, which will reside in OEI and will be managed by a developer. Direct access to WRApp will be through the Science Portal and other options for access (e.g., FTP, grid, and other links) will also be made available.

To enhance accessibility and functionality, this involves interoperability of data access and existing tools and efforts are underway to explore some of the new software that EPA has to offer on how to do this. Searches can be performed to come up with applications for use in decisionmaking use, and models and applications can be downloaded. An example of outputs was provided in a demonstration that also showed the ability to bundle data for applications to help promote consistent use of data.

The concept to manage data flows is in the pilot phase. There has to be a data owner, access to data, and an organization responsible for warehousing data such as the Safe Drinking Water Information System and those organizations can help to flow the data to WRApp. Next, a data steward is needed to coordinate experts to help with data transformations; while some are ongoing now, the desire is to coordinate all of this in one place. Once the data are coming in, there is a need for algorithms to transform the data and the data must already be tagged to know what transformation is needed. Finally, the data are made available through a mechanism such as WRApp. Since EPA is looking for an interoperable concept, this needs to be available to other applications besides WRApp. This is accomplished by providing access to bundled data sets and tools for decisionmaking through a web server so there is one main entry point and users do not have to search everywhere for what is needed for analysis. The tools being populated into WRApp focus on what the states, EPA Regions, OEI, and the Council on Regulatory Environmental Modeling (CREM) are working on.

The last step is to coordinate and develop tools and data to fill specific needs. For example, a SAS tool is being developed to enable states that do not have the resources to purchase SAS or other statistics packages to leverage the EPA license through the web in order to conduct simple or complex statistics without having to know how to program SAS. Also in development is the creation of links to EIMS—one of the large databases available within EPA to find applications, data sets, etc.—and the Registry of Environmental Applications Database, which enables users to go to one place, do a search, then look at a many large data bases that can support decisionmaking processes.

CREM Pilot Water Quality Model Selection Tool

Elsie Sunderland, with NERL, discussed the development of guidance and tools to assist in the selection of water quality models. The Data Quality Act and the information quality guidelines created new standards for the data that EPA disseminates and also sets some quality standards for how EPA does its science.

One major project in the last year was to prepare a draft guidance document on the development, evaluation, and application of all models at EPA and a knowledge base of the most frequently used models at EPA. There was also a directive to integrate this work across EPA, make the information available to the EPA Regions, and to ask the EPA Regions and states what they need.

The guidance sets forth a process to generate quality information and to determine when a model is sufficient to support a regulatory decision. Some of the principles of model evaluation are documented in the knowledge base to make the underlying science known and available. This guidance applies to all models at the EPA.

After the knowledge base was developed, a series of regional seminars were held to determine the modeling needs, what would make modeling efforts easier, interests in specific modeling applications,

and challenges within those applications. For example, EPA Region 10 was interested in a web portal to share case studies, data, and tools. The response back was to expand the CREM knowledge base within the area of water quality monitoring and to collaborate with the WRApp project and the Science Portal to make models and science underlying the models more available.

A second project is the development of a Water Model Selection Tool. This is a pilot tool with the goals of improving transparence in the model selection process, reducing duplication in model documentation (by having all models in one place and accessible), and centralizing access to a broad suite of tools and models with varying degrees of complexity. The concept is for this a tool to categorize/evaluate available models and establish a systematic process for model selection. The tool provides a ranking of the most appropriate models for the application specified based on relevance to specified criteria whether the modeling involves very simple empirical functions, mid-range complexity, or very complicated, dynamic simulation.

The underlying idea is that, out of the large universe of available models, there exists a smaller universe of those appropriate for application, a smaller universe of those that are most appropriate, and finally the model selected for use. The selection process involves selection of an indicator, water characteristics (e.g., land, water, special features), management/evaluation needs, application considerations, and user preferences that results in a list of applicable models ranked based on the specified characteristics.

The indicator selected needs to be relevant to specific management concerns; this might be a water quality standard or an indicator derived from an interpretation of a narrative criteria. An example is total phosphorus annual load, which includes both an indicator and a timeframe. Identification of land, water, and special features considers what type of system is involved (e.g., water body type, watershed, special features) as well as characteristics or features needed for that system. Model-specific features that affect ranking include ease of use, time to apply, difficulty, and user-specific preferences (e.g., availability of trained staff and experts, data, schedule, other constraints). The user-specified preferences section also enables the user to weight model ranking to address preferred model aspects. There also is a feature to look at proprietary and nonproprietary models; publicly available models can get a slightly higher ranking in the application consideration area.

The models are screened to select those that can simulate the indicators and a score is provided on how well each model matches the characteristics specified. The output is list of ranked models and the user can drill down into the ranking to look at the strengths and weaknesses of each model. The model listing can then be linked back to the metadata that is contained in the CREM knowledge base.

The tool records the entire model selection process, has an output function that shows the decision process, and documents metadata in the CREM knowledge database, past model evaluations, and past applications. This information can be saved in an online account. There also will be an administrative account to add more models and to update model scores. Discussions are underway regarding how to conduct future updates.

Anticipated benefits of this pilot tool include the following:

- Central location for models and evaluation tools
- Enhanced state-level access to available data, tools, and models
- Automated report function for model documentation.

There is also the ability to collect data on where (i.e., what context) different models are applied to help prioritize future research and development and to help understand model use.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) efforts still underway to fill in blank areas in the research and science architecture diagram; and (2) guidelines and mechanisms that are in development for submitting models to the knowledge database, associated legal issues for EPA, and a request for suggestions on how to accomplish this.

Section V: Office of Research and Development Track

Tuesday and Wednesday, May 17-18, 2005

The purpose of this breakout session on the second and third days of the meeting was to focus on the Scientific and Technological Achievement Awards program and research initiatives receiving these awards, green chemistry and green engineering research, impacts of airborne contaminants at high elevation/altitude National Parks, spatial analysis tools and applications, sustainable solutions for restoring degraded watersheds and ecosystems, environmental collaboration, and assessments of climate change. Each session included opportunities to respond to audience questions that provided additional information and insight on a variety of science, health, and environmental topics.

Tom Barnwell, with NCER, led a session addressing the Scientific and Technology Achievement Awards program and award recipients. Presentations included general information regarding the Science Advisory Board and the Scientific and Technological Achievement Awards Panel, and award-winning research on isolated wetlands and their functions, source sink balance and carbon allocation in below-ground plants exposed to ozone, and Toxicity Characteristic Leaching Procedure (TCLP) measurement of iron treatment for brass foundry waste.

Tom Barnwell, with NCER, led a session addressing additional examples of research receiving a Scientific and Technology Achievement Award. Presentations included with general information on the Scientific and Technology Achievement Award program and award-winning research on understanding the mechanisms for arsenic to cause cancer in humans, health effects of a waterborne amoeba and evaluation for potential regulation, and the relationships between blood lead concentrations and delayed puberty in girls.

Diane Bauer, with NCER, led a session addressing the next decade of green chemistry and green engineering research. Presentations included collaborations in green chemistry and engineering, industrial ecology applications of biolubricants in aluminum production, the green chemistry program at EPA, and technologies for a sustainable environment.

Dixon Landers, with the National Health and Environmental Effects Research Laboratory (NHEERL), led a session addressing a large-scale, interagency science project to evaluate the impacts of airborne contaminants on National Parks in the western U.S. Presentations included an overview of the Western Airborne Contaminants Assessment Project (WACAP), efforts to identify the presence and change over time of persistent organic pollutants in U.S. National Parks, USGS snow monitoring activities in support of WACAP, and the academic perspective on WACAP activities.

Luis Fernandez, with the Office of International Affairs (OIA), led a session addressing spatial analysis tools and applications for environmental assessments and management. Presentations included formation of an EPA work group on landscape ecology applications of spatial analysis tools and the use of spatial analysis tools for analysis of wildlife populations and risk assessment, streamlining the National

Environmental Policy Act (NEPA) screening process, decisionmaking for watershed management, and impacts of land use and land cover change.

Joseph Williams, with the National Risk Management Research Laboratory (NRMRL), led a session addressing sustainable solutions for restoring degraded watersheds and riparian ecosystems. Presentations included an overview of the EPA framework for ecological restoration research, a GIS-based decision tool for watershed restoration planning, modeling stream and riparian ecosystem restoration, challenges of stream restoration in increasingly developed areas, and water quality improvements through urban stream restoration.

Teresa Harten, with NRMRL, led a session addressing the ETV program and example verification activities. Presentations included an overview of the ETV program, diesel engine retrofit technologies to reduce emissions, field testing of ambient ammonia monitors, treatment systems to remove arsenic from drinking water, and ballast water treatment technologies.

Joel Scheraga, with ORD, led a session addressing public-private partnerships to understand, assess, and adapt to climate change. Presentations included activities in support of the U.S. Global Change Research Program, applications of an energy sector model to assess future air pollutant reductions achievable from potential transportation measures, research efforts to understand stressors of coral reefs and visualization tools to assist in measuring coral population changes, a GIS-based predictive model for wildfires and resulting value impacts to support planning and decisionmaking, impacts of climate change on water systems and combined sewer overflows, and efforts to understand how decisionmakers obtain and use scientific information to improve information dissemination and utility.

25th Anniversary of Scientific and Technological Achievement Awards (Session 1)

Following opening remarks by Tom Barnwell, with NCER, four speakers addressed the role of the Science Advisory Board and research that received a Scientific and Technological Achievement Award, including the an evaluation of isolated wetlands, source sink balance and carbon allocation, and TCLP analysis for treatment of contaminated sand from brass foundries. An audience question and answer period followed the presentations.

Science Advisory Board Scientific and Technological Achievement Awards Panel

Deborah Cory Schlechta, Chair of the Science Advisory Board's Scientific and Technological Achievement Awards Panel, discussed the role of the Science Advisory Board with the Scientific and Technological Achievement Awards, the review and recommendation process, and ideas for the future. The mission of the Science Advisory Board is to provide the EPA Administrator with outside, independent advice on the scientific and technical aspects of environmental issues to help inform environmental decisionmaking. In addition, the Science Advisory Board is to identify a wide range of scientific, engineering, economics, and social science issues that impact the technical bases of EPA policies, regulations, research, and science programs.

The Science Advisory Board has recommended recipients of the Scientific and Technology Achievement Awards to the EPA Administrator since 1980 in order to support good science throughout the Agency, reward and encourage excellence, and raise the visibility of EPA research in the scientific community. The Scientific and Technological Achievement Awards program has evolved and is seen as a positive management tool. The program first began with ORD; however, in 1987, the Science Advisory Board advised EPA to extend the program throughout the entire Agency. Additional award categories have also been defined and an increased number of submissions are received each year.

There are three award levels. Level 1 is the highest award and represents an exceptionally high quality research or technological effort that involves the creation or general revision of a scientific or technological principle or procedure, or a highly significant improvement in the value of a device, activity, program, or service to the public; must be of national significance or have high impact on a broad area of science/technology; and must have far reaching consequences and be recognizable as a major scientific/technological achievement within its discipline or field of study. The second criterion is potentially the most important.

For the review and recommendation process, a multidisciplinary panel is formed through an open panel nomination process. The panel holds closed meetings, evaluates papers by panel members with related expertise, and engages in an intensive process of deliberation to develop consensus ratings. The overall theme for the award process is stated as, "*We did not attempt to ensure equality of numbers or proportion of awards across the categories or laboratories. Rather, good science and technology were our sole criteria for recommending awards*."

Challenges for the future include how to increase transparency, deal with information overload, provide in-depth review of increasingly specialized science yet reward interdisciplinary collaboration, take advantage of changes in electronic journals and electronic peer review, and how to make EPA science more accessible to the public through information tools. Opportunities for the future include new approaches, such as electronic nominations, web-based access to articles, new technologies for electronic meetings, and web-enabled posting of nominated articles. The Science Advisory Board believes that the Scientific and Technological Achievement Awards are here to stay because excellence in science needs to be recognized and peer review is the currency of science.

Isolated Wetlands and Their Functions: An Ecological Perspective

Scott Leibowitz, with NHEERL, discussed a U.S. Supreme Court decision on how to define waters of the U.S., which prompted the need for information regarding isolated wetlands. The Clean Water Act (CWA) defines waters of the U.S. as "navigable waters" and defines intrastate waters as including lakes, rivers, streams, or wetlands that the use, degradation, of destruction of which could affect interstate commerce. The regulatory preamble provides examples of commerce links, including: (1) the use as a habitat by migratory birds, (2) the use as a habitat for endangered species, and (3) the use to irrigate crops sold in commerce. The Supreme Court decision for the Solid Waste Agency of Northern Cook County ruled that the "Migratory Bird Rule" is not fairly supported by the CWA, as the mere presence of migratory birds cannot be used as a basis for asserting CWA Section 404 jurisdiction over isolated, non-navigable, and purely intrastate waters. As a result, the need was recognized for research to show an indirect connection to commerce, specifically for isolated waters, in addition to better understanding the science behind isolated waters.

An "isolated wetland" is a recent term and is not used consistently across the literature. Current definitions include both hydrological and biological components, but require detailed information. As a result, the U.S. Fish and Wildlife Service came up with the term "geographically isolated wetlands," which is a more practical definition for field personnel. Examples of geographically isolated wetlands include prairie potholes, playa lakes, the Carolina bays, and California vernal pools. National estimates of wetlands are not very good, nor has research tracked changes over time as a result of various impacts.

The research could not make a rigorous comparison, as no standardized approach exists; however, several conclusions were made. First, an isolated wetland was identified as not functionally homogenous; occurring over a wide geographic, environmental, and climatic range; and performs many of the same functions as non-isolated wetlands. Further, the question arises as to whether such wetlands are isolated because there are a variety of connectivity examples, such as: (1) wetlands having a hydrologic connection by ground water as well as intermittent surface water connections, and (2) wetlands have a biotic connection through dispersal and distance between wetlands, flood frequency, and dispersal distance.

Isolation should be treated as a spatial and temporal continuum and not viewed as a discrete, generic property. In addition, juxtaposition of isolation and connectivity may uniquely shape isolated wetlands as a resource. Further, a semi-isolated system may be present. Several maps and figures illustrated how the connectivity features can be mapped to indicate the relationships. These relationships can then potentially show the connection of isolated waters and waters of the U.S. Further research is needed to document the functions and values, to develop methods to assess hydrologic and biotic connections to waters of the U.S., to assess contributions to broader CWA goals, and to develop rapid assessment techniques.

Source Sink Balance and Carbon Allocation Below Ground in Plants Exposed to Ozone

Christian Andersen, with NHEERL, discussed air quality standards, aboveground and below ground ecosystem complexity, findings of ozone effects on soil organisms, and scaling plant-level responses to ecosystems. The CAA defines two types of NAAQS: primary standards to protect human health and secondary standards to protect public welfare from "adverse effects." Secondary standards include effects to ecosystems, forests, soils, and crops, and are the focus of this presentation.

Ozone impacts on ecosystems are evaluated by reduced plant growth and yield, ecosystem structure and function, species diversity, and ecosystem services. However, the majority of the information available pertains to reduced plant growth and yield. The most challenging part of ecosystem protection is the

response of species over years to decades, as there are thousands of species with differential sensitivity and numerous types of species interactions. Photographs depicted examples of two Ponderosa Pine communities, within the same air shed, that looked vastly different. Further, the complexities increase when moving from aboveground to below ground. One suggestion is to construct food webs based upon the processing of carbon to understand the below ground section. Cross-sections and illustrations depicted how carbon moves through such a system.

Since healthy ecosystems require healthy soils, does ozone affect soil organisms? Illustrations showed how ozone enters through the plant that, through source sink, brings the ozone to the soil. Ozone does not penetrate the soil and any effects in soil are an indirect result of changes to the plant. Ozone alters the source sink balance and an illustration demonstrated the movement of ozone and carbon in plant and soil. There is a lot of information about this movement, including retention of carbon in leaves from ozone, increased respiratory costs associated with repair costs, altered leaf tissue chemistry, and ozone altering the timing and amount of carbon reaching the below ground system. However, there is a limited understanding of the overall effect on the food web, as there is limited understanding. Therefore, we need to look at indicators of change, such as the amount of carbon dioxide being released from the soil, the microbial biomass and ratio of carbon dioxide to microbial biomass, and the development of soil carbon below ground.

NHEERL is looking at these types of indicators in chambers using plant and vegetation mixtures to evaluate the impacts. In addition, NHEERL is working in Germany where scientists are exposing mature trees to ozone. Despite current understandings, we are not yet able to predict what is happening in soils as a result of ozone stress. Below ground responses were often unpredictable based on plant-level understanding and below-ground responses occur rapidly, often before aboveground responses. However, evidence suggests that ozone may alter ecosystem carbon pools through atmospheric feedback with climate change and carbon dioxide releases to the atmosphere, ozone may alter ecosystem nutrient cycling through water quality and plant productivity, and below ground changes may alter vegetation through feedback with ecosystem services.

Toxicity Characteristic Leaching Procedure and Iron Treatment of Brass Foundry Waste

Douglas Kendall, with the National Enforcement Investigations Center in the Office of Enforcement and Compliance, discussed characteristics of hazardous waste and challenges of toxicity testing using a case study of the treatment of brass foundry waste. Brass foundries contain copper, zinc, and lead, and the lead is generally from recycled brass in cars. Molten brass is cast in sand molds; the waste sand is considered hazardous and is subject to the TCLP test for lead, since copper and zinc are not required to pass TCLP tests under RCRA. The TCLP procedure involves an 18-hour extraction using greater than 100 grams of waste; 0.1 M of acetate is used to perform the extraction and the pH varies from 2.93 to 4.93. These conditions are meant to simulate a landfill.

Analytical results for waste sand samples showed 5 mg/L of lead, which is 10 times over the regulatory limit that defines a characteristic hazardous waste under RCRA. It was found that if 10 percent iron metal was added to the waste sand, the lead extracted in the TCLP analysis would decrease to below regulatory levels and a nonhazardous waste landfill could accept the waste. After the iron addition, lead and copper levels greatly decreased in the sample; however, zinc levels greatly increased.

EPA Region 6 removed waste sand from a landfill, subjected it to a TCLP test, and found that lead was being extracted at more than the regulatory limit, which indicated that iron treatment at the landfill was failing. Since the iron treatment was reducing lead levels in the TCLP test, but not in the landfill, researchers looked at what else could be happening in the landfill. The researchers examined the

chemistry in the landfill, including oxidation states and oxidation requirements. Since a landfill is in the open and the TCLP test is conducted in closed containers, two reactions were examined: (1) precipitation of hydroxides and (2) sorption by hydrous ferric oxide. Graphs and figures illustrated the different types of iron present in the TCLP test as compared to the landfill samples, the precipitation of hydroxides, and the sorption by hydrous ferric oxide.

TCLP tests are influenced by several factors and pH is the primary factor. The TCLP test was constructed in order to stimulate landfill conditions, but several other tests have been devised to simulate varying conditions. Since it is problematic to ask a generator to pass several tests, the question arises as to how to determine which test is most applicable.

Research concluded that the iron treatment was not a long-term stabilization method because, in the landfill, iron metal will oxidize and hydrous ferric oxide may form and absorb lead, copper, and zinc. The suggestion of this research is to look at all totals to see if regulation is required and subsequently to determine if the waste is suitable for disposal. This would determine which test the generator needs to pass.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) the availability of lists of Scientific and Technological Achievement Awards for previous years and Science Advisory Board reports online at http://www.epa.gov/science1; (2) the limited availability of models for the soil ecosystem and carbon transfer below ground and the greater availability of models that look at the total amount of carbon going below ground and simpler models for agricultural systems; (3) how the NHEERL research on ozone effects on soil is not considering the secondary products of ozone reactions, which are also reactive but are so short lived that they are not of much concern; (4) the difficulty of separating concurrent ozone and high nitrogen impacts with the greatest impact anticipated to occur at the litter layer; (5) linkages in the NHEERL research on below ground carbon to impacts on aquatic systems and the likelihood of seeing changes not only from the carbon perspective but from the nutrient standpoint as well regarding nutrient movement in surface water; (6) how much of the information on the effects of ozone are at the plant level rather than the ecosystem level; (7) the potential for EPA to reconsider the current secondary NAAQS standard, which would require a determination that the current standard is not sufficiently protective of ecosystems; (8) background on the enforcement case underlying the sampling of waste sand from a brass foundry, how the facility must now monitor the groundwater for the disposed waste and manage the current waste as a RCRA hazardous waste, and how these activities led OSWER to a successful prohibition of such iron treatment, (9) how there are many examples of conditions in the environment or a landfill are very different from those in a short-term leaching test such as the TCLP and the difficulties in designing a leaching test that will apply to all situations.

25th Anniversary of Scientific and Technological Achievement Awards (Session 2)

Following remarks by Tom Barnwell, with NCER, four speakers addressed the Scientific and Technology Achievement Awards and award-winning research including the mechanisms by which arsenic causes cancer in humans, health effects of an amoeba found in drinking water, and the potential for blood lead concentrations to delay puberty in adolescent girls. An audience question and answer period followed the presentations.

Scientific and Technological Achievement Awards

William Farland, Acting Deputy Assistant Administrator for Science, discussed the Scientific and Technological Achievement Awards, criteria for eligibility, award statistics, the selection process, and award recognitions. The Scientific and Technological Achievement Awards promote and recognize scientific and technological achievement by EPA employees and are the most prestigious of EPA's scientific award programs. The Scientific and Technological Achievement Awards involve an agency-wide competition sponsored by ORD that recognizes outstanding scientific and technological publications by EPA employees. Publications are reviewed and evaluated by the Science Advisory Board, which produces recommendations that ORD uses to select the actual awards. The Scientific and Technological Achievement Awards make the general public more aware of the quality and depth of EPA science, and improve the credibility of the science underpinning EPA decisions on important issues.

To be eligible for a Scientific and Technological Achievement Award, the research must be published in a peer-reviewed journal, initiate or revise a scientific principle or procedure, and be recognized as a major achievement within its field of study. Further, only EPA employees are eligible and all aspects of science, including health and ecological effects, environmental exposure, risk assessment, and risk management, are eligible.

There are four award levels: Level 1 awardees receive $5,000, a congratulatory plaque, letter of appreciation, and a certificate; Level 2 awardees receive $2,500, a letter, and a certificate; Level 3 awardees receive $1,000, a letter, and a certificate; and Honorable Mention awardees receive a letter and a certificate. Monetary awards are distributed according to each author's contribution to the total effort, and awards are extremely competitive. There are increasing numbers of applications and awards given each year.

An abbreviated list of 2005 awardees was presented, in addition to professional society and post-doctoral recognitions and a bibliometric analysis of EPA published papers. The Scientific and Technological Achievement Awards provide a means of special recognition for employees who have excelled in scientific and technical disciplines. Awards are given in conjunction with the appropriate professional society or association in scientific or technical areas related to the broad field of environmental protection. This year, Scientific and Technological Achievement Awards went to scientists and engineers from EPA Regions 4 and 9, the Office of Air and Radiation, the Office of Pollution Prevention and Toxic Substances, and ORD.

Methylated Trivalent Arsenicals as Candidate Ultimate Genotoxic Forms of Arsenic

Andrew Kligerman, with NHEERL, discussed background information about arsenic, carcinogenic factors, research needs, and subsequent research findings and conclusions. Arsenic is the 20th most abundant element in the earth's crust. It is a metalloid and is usually found in the environment as arsenate. Human exposure to arsenic is widespread and arsenic is common in many groundwaters and surface waters used for drinking water. Further, many seafoods contain arsenic, and there can be exposures from smelting, mining, pesticide use, and waste disposal.

Arsenic is a known human carcinogen. In drinking water, it is associated with increased rates of bladder, kidney, lung, and liver cancer. The current risk assessment for arsenic is based on bladder cancer data.

There are no good animal models to show how arsenic causes cancer; however, there have been some recent efforts to test arsenic exposures in rodents. The issue needs to be addressed to reduce the uncertainty in risk assessment and to better understand the causes. Possible ways arsenic can cause

cancer include altering DNA methylation, changes in cell signaling, being a co-carcinogen, cell death and proliferation, and inducing genetic damage. The research presented is the first comprehensive study of the potential genotoxicity of both the inorganic and methylated metabolites of arsenic. Methylation was originally thought to be only a detoxification pathway. Further, pentavalent methylated arsenicals are the major metabolic products in humans. Small amounts of trivalent methylated arsenicals have also been detected in humans and other mammals. An illustration depicted the reduction and methylation pathways for arsenic.

There are several forms of arsenic: inorganic arsenate [AsV], inorganic arsenite [AsIII], monomethylarsonic acid, monomethylarsonous acid, dimethylarsinic acid, and dimethylarsinous acid. Research questions included, which forms of arsenic have the ability to damage DNA, what types of genetic damage are produced, and which forms are the most potent genotoxins. Human cells, including single cell gel assay, sister chromatid exchange, and chromosome aberrations, were used in the study. In addition, *Salmonella* bacteria, as a prokaryotic gene mutation assay, and LY5178Y/*Tk*-/+ mouse cells in culture were used. Charts indicating DNA damage in human lymphocytes, sister chromatid exchange induction, chromosome aberration, the potency of arsenicals in human lymphocytes, and the mutagenicity of arsenicals in a mouse lymphoma assay were shown. Further, impacts on subject organisms were evaluated.

Results of the research indicated that methylated pentavalent arsenicals are relatively nontoxic, methylated trivalent arsenicals are potent DNA strand breakers and cause chromosome aberrations, none of the arsenicals tested induce point mutations, and the damage induced by trivalent methylated arsenicals is indicative of agents that act through free radical production. This study is the first comprehensive investigation of the genotoxicity of the inorganic and organic metabolites of arsenic, showing that methylation of inorganic arsenic leads to highly genotoxic products. Further, the research concluded that monomethylarsonous acid and dimethylarsinic acid are the primary forms of arsenic that are responsible for its genotoxicity and, hence, play an important role in the carcinogenic mode of action of arsenic.

Health Effects of *Acanthamoeba* spp. and Its Potential for Waterborne Transmission

Nena Nwachuku, with the Office of Science and Technology, discussed the statutory requirements for the EPA Contaminant Candidate List (CCL), the criteria for regulatory determination by EPA, significance of the *Acanthamoeba* study, the definition of *Acanthamoeba*, and its occurrence, health effects, risk factors, populations at risk, diagnosis, and treatment. The health effects study (EPA-822-R-03-012) provides the scientific basis and helped the EPA Administrator make the "Do Not Regulate" determination decision about placing *Acanthamoeba* on the CCL. The 1996 amendments to the Safe Drinking Water Act (SDWA) require EPA to publish a CCL list every 5 years, make regulatory determinations on at least five contaminants, and use three criteria to determine whether to regulate: (1) the contaminant may have an adverse effect on human health; (2) the contaminant is known to occur or there is substantial likelihood that the contaminant will occur in a public water system with a frequency and at levels of public health concern; and (3) in the sole judgment of the EPA Administrator, regulation of such a contaminant presents a meaningful opportunity for health risk reduction for persons served by a public water system.

Acanthamoeba is a free living amoeba. There are 20 species in the genus, which are classified into three groups based on cyst morphology. Widespread in the environment, it feeds on bacteria and can possibly engage in a symbiotic relationship. Few species are capable of causing disease in humans; however, it can be associated with contact lens infections. Further, *Acanthamoeba* is commonly found in aquatic environments; has been detected in 50 percent of surface water in recreational areas; has been shown to be transmitted through hot tubs, bottled water, and tap water; and is capable of growing in water distribution systems after conventional treatment.

The two major illnesses associated with *Acanthamoeba* are Granulomatous Amoebic Encephalitis and *Acanthamoeba* Keratitis (AK). An illustration depicted the life cycle of an *Acanthamoeba* infection in a human. *Acanthamoeba* is the only microbe that can cause the most devastating and potentially blinding infection in humans, and statistics indicate that those who wear contact lenses are most susceptible to infection; however, conditions that can increase exposure, in addition to contact lenses, include eye trauma or enhanced exposure to *Acanthamoeba*. The cornea is a target site, as it is a warm, moist, exposed environment that is constantly challenged by microbes. The eye naturally protects itself with the tear film and with blinking. Risk factors associated with contracting the infecting include the use of tap water to wet or store contact lenses, bottled water to wet or store contact lenses, non-sterile solutions to wet/store contact lenses, wearing contact lenses during swimming, wearing contact lenses in hot tubs, swapping contact lenses, and wetting contact lenses with saliva.

The EPA decided that the critical control point identified for AK in contact lens wearers is personal hygiene and not drinking water. Therefore, there is no meaningful opportunity for health risk reduction for the general population by regulating *Acanthamoeba*. If consumers adhere to contact lens manufacturer instructions for storage and rinsing with sterile solutions, incidents of AK will be reduced. For public health protection, EPA has developed a guidance and outreach products for contact lens wearers and health care providers.

Blood Lead Concentrations and Delayed Puberty in Girls

Sherry Selevan, with NCEA, discussed research conducted on blood level concentrations and delayed puberty in girls using a public survey to obtain the data. Environmental contaminants have been associated with earlier puberty in girls and later puberty in both boys and girls. Lead exposure could affect the timing of puberty indirectly and directly. Indirect effects include exposure associated with growth restriction in animals and humans and timing of puberty associated with growth and maturation (e.g., body mass index, weight, and height). However, the endocrine system could experience direct effects to the hypothalamic-pituitary-gonadal axis, in addition to effects on calcium homeostasis and bone growth.

Data for the analysis was obtained from the National Center for Health Statistics at CDC. A cross-sectional, nationally representative, complex survey was conducted from 1988 to 1994 and was designed to provide estimates of the health status of the general population. Data on girls from three ethnic groups (non-Hispanic white, non-Hispanic African American, and Mexican American) that had blood level measurements and experienced one or more measures of puberty were used. In addition, due to the complexity of the survey, special parameters had to be implemented.

A graph depicting blood levels by age indicated that overall lead levels were below 10 mg with the exception of only a couple data points. A table of data showed the Tanner Stage and blood level concentrations, and these data indicated that African Americans and Mexican Americans demonstrated delayed breast and pubic development. The data also indicated that African Americans exposed to lead experience delayed menarche.

Blood lead levels were inversely associated with height, but were only associated with delayed puberty after correction for body size, which suggests effects through the neuroendocrine system. Also, all measures of delayed puberty were significant for African Americans, Tanner stages were delayed for Mexican Americans, and no signs of delayed puberty were significant for non-Hispanic whites. Further, overall blood levels were very low. Note that the research may not have included critical windows of development, there may be a need for a longitudinal study that gets measures at different points in time, and there may be other environmental or biological factors.

Questions and Answers

The speaker had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) indications that the trivalent form of arsenic is critical to enabling movement into a cell and information from a recently published paper that appears to indicate that the pentavalent form may be necessary for arsenic to enter a cell; (2) the trivalent form of arsenic being the one that in a cell triggers the formation of free radicals and that is what causes the DNA damage and in turn results in cancer; (3) how evaluations of Granulomatous Amoebic Encephalitis did not find the facial pathway (e.g., from face into sinuses) to be the route of entry; (4) the lack of worldwide data since the original outbreaks of Granulomatous Amoebic Encephalitis and how the incidence rate of 1.625 per year per 1 million persons is barely higher than the EPA risk goal of one incidence in 1 million persons; (5) the much higher rate of AK incidents than those for Granulomatous Amoebic Encephalitis; (6) how those who wear contact lenses on a short-term basis (e.g., change daily) have a higher incidence of AK infection than those who wear the long-term lenses (e.g., change weekly) and how that infection rate is related to the frequency of contact lens removal, cleaning, and storage in a solution in a case; (7) difficulties of removing *Acanthamoeba* at the water treatment plant since it is resistant to disinfection agents such as chlorine and ultraviolet light; (8) the ability to use of filtration to remove *Acanthamoeba* in drinking water for at least one of the three cyst forms; (9) difficulties in comparisons of breast development to measure delayed puberty because of different morphologies that are dependent on the genetic background of the individual; and (10) recognition that breast development is a challenging measure that must be done consistently by well-trained persons and the resultant difficulties in comparing such data across studies.

Informing the Next Decade of Green Chemistry and Green Engineering Research

Following opening remarks by Diane Bauer, with NCER, four speakers addressed research on collaborations in green chemistry and engineering, industrial ecology applications of biolubricants in aluminum production, the green chemistry program at EPA, and technologies for a sustainable environment. An audience question and answer period followed the presentations.

Collaborations in Green Chemistry and Engineering in ORD

Douglas Young, Chief of the Clean Processes Branch in NRMRL, discussed EPA experience with green reactor design, solvent strategies, catalyst design, membrane technologies, and absorbents as well as extramural expertise and future directions. The Clean Processes Branch has developed expertise in alternative reactor designs and their applications. The Spinning Tube-In-Tube reactor was not developed by EPA; however, evaluations of this reactor show that it allows for high mass transfer and leads to faster reactions. The Clean Processes Branch has designed Photocatalytic and Continuous Flow Microwave reactors; some have lower or higher reaction times and specific reactor designs can benefit specific processes. Ozone Corona is another reactor being studied; while the Clean Processes Branch did not design this reactor, there has been much research regarding processes that can benefit from its use.

The Clean Processes Branch has developed other green chemistry processes for solvent usage. These methods include solvent free synthesis (e.g., microwaves, ultrasound), greener solvents (e.g., water, polyethylene glycol), supercritical carbon dioxide, and ionic liquids (e.g., gas-phase reactions). In addition, the Clean Processes Branch has researched catalyst design with a specific focus on a catalyst that partially oxidizes hydrocarbons. EPA has an agreement with Solutia for the design and testing of OSCAR, which is a one-step catalyst that uses oxygen, decreases energy consumption, and performs a 65

percent conversion; benefits include materials and energy savings, elimination of nitrous oxide generation, and regeneration to nitric acid.

Two membrane technologies are also being researched: recovery of biofuels from biomass waste and dehydration of alcohols and other solvents. EPA is teaming with a number of partners regarding recovery of biofuels, including membrane development and pilot-scale usage in real systems. In the area of dehydration of alcohols and other solvents, water is being separated out using distillation; wile the energy requirement is intensive, the process is well established.

The Clean Processes Branch has also developed an in-house absorbent (made of a very common, inexpensive material) to remove vapor phase mercury from flue gas at coal-fired power plants. This novel absorbent is made of clay (dirt) and common metals. Bench-top testing and a small-scale pilot test have been conducted and a medium-scale pilot test will soon be conducted.

Extramural developments of green chemistry include chemical synthesis by John Frost, a student at Michigan State University, who explored the use of microbial biocatalysts to synthesize resorcinol, a chemical used in the manufacture of useful materials such as adhesives and ultraviolet radiation blockers. The process utilizes a renewable, environmentally benign feedstock, glucose, in place of benzene. In addition, Joseph DeSimone, at the University of North Carolina, developed a surfactant that dissolves in carbon dioxide for use in the dry cleaning process and eliminates the use of harmful organic solvents known to pollute groundwater and air; Mr. DeSimone has commercialized this process and has started a successful chain of dry cleaning stores.

Future directions of green chemistry include the identification of areas where typical uses of priority chemicals can be minimized or improved, use of microwave-based chemistry for pharmaceutical/specialty chemical applications, and combining pervaporation with other technologies.

Industrial Ecology Applications: Biolubricants in Aluminum Production

Thomas L. Theis, with the University of Illinois at Chicago, discussed the concept of industrial ecology and provided an example of using soybean oil to replace mineral oil in industrial processes. Industrial ecology is the means by which humanity can "*deliberately and rationally approach and maintain sustainability, given continued economic, cultural, and technological evolution.*" The concept requires that an industrial system be viewed, not in isolation from its surrounding systems, but in concert with them. It is a systems view that seeks to optimize the total materials cycle from virgin material, to finished material to component, to product, to obsolete product, and to ultimate disposal. Factors to be optimized include resources, energy, and capital. A timeline depicted historical approaches to environmental management, including the role of EPA, conceptual models, primary focuses, and disciplinary approaches.

Development of a biolubricant involved collaboration with the USDA National Center for Agricultural Utilization Research. Biolubricant testing and assessment has been conducted at the University of Illinois at Chicago. Research questions included the following:

- What is the feasibility for biolubricants in the overall market (e.g., costs, consequences)?
- What are the decisionmaking factors (e.g., adoption, performance, costs, others)?
- How does technological change occur (e.g., driving forces, management structure)?

Over 1 billion gallons of industrial lubricants are consumed annually in the U.S, and 30 to 40 percent are released to the environment through spills, leaks, evaporation, and indirect means. There is an increased

interest in green substitutes, as 98 percent of vegetable oil is used for food applications and may be increasingly less available for industrial applications.

Soybean oil was chosen for this study due to abundance, oil yield, lubricity, data availability, and concurrent research initiatives. In addition, modifications such as hydrogenation, transesterification, or epoxidation increase its oxidative stability. Laboratory results indicate that soybean oil is slipperier than traditional mineral oil. Further, trial results showed biolubricant formulations were superior to traditional lubricants as they could handle higher loads, have better surface quality, and reduce volatile organic carbon emissions; however, stability issues are still questionable.

An Environmental Assessment suggested that the soybean oil was technologically superior, but questioned whether biolubricants were really greener. In addition, agriculture requires large amount of fossil energy and synthetic chemicals. As a result, a life-cycle assessment was conducted that compared the use of mineral oil and soybean oil, including the life cycle of air emissions, non-point agricultural runoff water quality issues (since high nitrate concentrations can lead to unsafe drinking water), and increased non-point pollution from erosion and pesticide runoff.

The manufacturing and disposal stages will ultimately determine desirability of the lubricant. Possible outcomes will include a decrease in volatile organic compound emissions, decrease in material use, readily biodegradable waste, oxidative stability, microbial contamination, sensitive worker populations, performance characteristics, surface quality, and overall cost.

Green Chemistry Program

Richard Engler, with the Office of Pollution Prevention and Toxics, discussed the definition, founding principles, demonstrated benefits, and measurable results of green chemistry. In 2002, 4.3 billion pounds of TRI chemicals were reported as released to the environment by TRI-reporting facilities. The Green Chemistry Program was initiated in response to the Pollution Prevention Act of 1990, and established a risk management hierarchy. At the bottom of this hierarchy is proper waste disposal (i.e., not just dumping the waste). The next level is treatment—it is better to treat waste to reduce its hazard before disposal, but recycling is even better because, by using the substance again, the need for virgin materials is reduced. Finally, at the top of the hierarchy is source reduction, which is true pollution prevention, where the waste is not made in the first place. If there is no waste, then the lower tier components of the hierarchy do not have to be addressed.

Risk is a function of hazard and exposure and can be minimized by reducing hazard and/or exposure. Green chemistry is pollution prevention at the molecular level, and involves the design of chemical products or processes to reduce or eliminate the use or generation of hazardous substances. Principles of green chemistry include the following:

- Prevent waste
- Maximize atom economy
- Design less hazardous syntheses
- Design safer chemical products
- Use safer solvents and reaction conditions
- Increase energy efficiency
- Use renewable feedstocks
- Avoid chemical derivatization
- Use catalysts not stoichiometric reagents
- Design chemical products to degrade after use
- Analyze in real time to prevent pollution

- Minimize the potential for accidents.

The green chemistry mission is to promote the research, development, and implementation of innovative chemical technologies that reduce or eliminate the use or generation of hazardous substances from chemical manufacture and use. Designs originate through awards, small business development, fundamental research, etc. The Green Chemistry Program provides recognition for outstanding green chemistry technologies through the annual Presidential Green Chemistry Challenge Awards. This national recognition has been very successful in educating chemical manufacturers and users on the scientific, economic, and environmental benefits that green chemistry technologies offer. This in turn has been very effective in promoting necessary behavior change, thereby encouraging further developments in the area. The success of this awards program has lead to several other countries (including Australia, Italy, Japan, and the United Kingdom) to launch similar, if not identical, awards programs.

Green chemistry also provides measurable results. Through education and assistance, a voluntary partnership program is enabling the U.S. chemical industry to design chemical products and commercialize chemical processes that have proven, measurable benefits to human health and the environment and that are economically competitive. This allows the U.S. industry to maintain its global competitiveness (perhaps even providing a competitive advantage), while ensuring a sustainable future. This is being demonstrated through the measurable benefits to human health and the environment. For example, the 46 award-winning technologies prevent the use and generation of 120 million pounds and 2.2 million gallons of hazardous chemicals, and save 55 million gallons of water each year.

These numbers represent the "best of the best" of green chemistry technologies. A metrics tool is currently being developed to better quantify the benefit of all 600 nominated technologies, and the results are anticipated to be one to two orders of magnitude higher. Additional information on green chemistry can be found at: http://www.epa.gov/greenchemistry.

Technologies for a Sustainable Environment

Delcie Durham, with the NSF, discussed the Technologies for a Sustainable Environment (TSE) program and examples of research activities underway. NSF efforts research and collaboration efforts 8 years ago focused on green chemistry and green chemical engineering, involving about 95 percent of the 200 to 250 proposals received each year. An industrial ecology viewpoint began to emerge and NSF research interests began to focus on effects on the environment from the manufacture of products (not chemical); this included efforts to build a community and a sense of stewardship among design engineers and those involved with manufacturing to look at the environmental impacts of what they are doing. This concept evolved further into environmentally benign design and manufacturing or environmentally conscious manufacturing. Initial research efforts in this area involved the elimination of lubricants from metal cutting; however, this concept further evolved to more of a systems approach to consider all of the effects (e.g., air, operations, etc.) from such actions.

Interest in these concepts grew within NSF and enabled the research interest to expand from the design, manufacturing, and industrial innovation area into construction and civil/mechanical engineering aspects. NSF started a new initiative for product realization and environmental manufacturing of innovative systems for eco-efficiency, which requires the research projects to be interdisciplinary and involve industrial collaboration. The latest initiative focuses on materials use science engineering and society, and fosters collaborations to consider the social impact and research needed to look at consumption, economic modeling, consumption demand, resource use, etc. This evolved from grant challenges involving material reuse and fit and meshes well with other NSF activities to develop technologies for materials substitution or pollution prevention.

This background demonstrates how the NSF programs have continued to expand in topic, bring green chemistry and related concepts to a broader audience, and develop collaborations to continue research in this area. The current initiative has $2 million in funding for 5 years, is highly disciplinary, cuts across all engineering, and is inclusive of social science, economic research, and materials research. There is an NSF awards database that has abstracts on all of the projects.

In 2000, much of the research focus was on cleaning technologies such as low temperature plasma and cleaning without solvents. By 2001, topical areas of interest expanded. For example, Pennsylvania State University looked into processes to reduce gaseous emissions from foundry operations and the new processes put in place to control outgassing not only prevented pollution in casting, but was providing higher yield and higher quality material on the production side. Topics of interest also included material substitutions for polymer composites and micromolding of aluminum parts.

In 2003, NSF developed a new research solicitation that included life-cycle assessment, green design and materials cycles, and environmentally benign manufacturing, and received 77 proposals. These have greater emphasis on a systems approach (e.g., what effects are) whereas past interest would have focused on the process alone. Proposal reviewers today consider such questions as: How would it affect the whole environment? Will another hazard be created? Are there higher energy requirements? Have air impacts been considered?

Several examples of funded projects were presented:

- Use of ultraviolet light to cure polymers for enhanced paint and adhesive performance. This is an environmentally benign manufacturing process that involves the materials down to the atom level. This is fundamental research that can have a significant impact on the automobile industry by 2010 such as color selection and coating performance.

- Impacts of materials substitution in the manufacture of paper. The pulp and paper industry is the largest air polluter and this effort looks at the effect of substituting mimosa for other plant material used in paper manufacture—on the processing, reduction of bleaching, paper quality, and energy requirements. Mimosa is fast growing and brings different requirements to the whole scheme of pulp and paper manufacture. Such a change is risky, but NSF is particularly interested in looking at such possibilities in the front end to see if they are worth pursuing.

NSF is also interested in expanding the "reduce, reuse, and recycle" concept to include demanufacturing. This involves the introduction of remanufacturing into product design to reduce the need to go to the recycling step, and is considering multiple lifecycle aspects (e.g., keeping the cycle closed by keeping the material in usable categories), not just total lifecycle management.

The TSE program has helped NSF get the research community involved in areas much broader than green chemistry. Some near-term areas of research interest involve concrete (e.g., how to recycle it, toughen it, and improve its characteristics and performance), bio-based products such as soybean use in polymer composite manufacture and other areas (e.g., resource use and needs, sociological impacts on rural economy by increasing soybean cultivation), corrosion, and lifecycle assessment.

Questions and Answers

The speaker had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) challenges posed to continued research involving green chemistry given planned budget reductions within EPA and how such reductions are at a difficult stage in the development process as many technologies researched in the past

few years are just now beginning the implementation stage (e.g., pilot scale); (2) outreach to chemists who have not heard of green chemistry through the American Chemical Society, the American Chemical Education Foundation, trade shows, and presentations to various audiences; (3) the importance of grant money to continue academic interest in green chemistry; (4) opportunities for EPA to review processes and make recommendations for process and product improvements under the new chemicals program established under the Toxic Substances Control Act, which allows for confidentiality for business information; (5) the difficulties in providing feedback when a chemical is at the commercialization stage and how such feedback is more beneficial at the bench-scale level where the design decisions are being made about the product or process design; and (6) the strategic NSF decision to add the term "systems" into program titles and NSF emphasis on promoting sustainable manufacturing.

A Large Scale, Interagency Science Project to Evaluate the Impacts on Airborne Contaminants in the West

Following opening remarks by Dixon Landers, with NHEERL, three speakers addressed the assessment of airborne contaminants in National Parks, the presence of persistent organic pollutants in the National Parks and their potential risk, USGS monitoring activities in the National Parks, and collaboration with academic institutions. An audience question and answer period followed the presentations.

Western Airborne Contaminants Assessment Project

Dixon Landers, with NHEERL, discussed the purpose, objectives, research questions, study sites, and timelines for WACAP. Man-made airborne contaminants are found in high altitude sites in the western National Parks. Trans-Pacific sources contribute to these airborne contaminants, such as a large dust cloud detected over China in 1998 by satellite imagery, and this contribution is expected to increase as the Asian population is expected to grow to from 1 billion to 3 billion by 2025.

The goal of WACAP is to assess the deposition of airborne contaminants in western National Parks and to provide regional and local information on exposure, accumulation, impacts, and probable sources. Key science and ecological questions include:

- Are contaminants present in western National Parks?
- Where do contaminants accumulate ecologically and geographically?
- Which contaminants pose the greatest ecological threat?
- Which indicators are the most useful in interpreting contamination?
- What are the probable sources of the air masses most likely to have transported contaminants to the National Park sites?

Current air sampling locations are not at high altitude, and methods have not been developed to adequately sample air at high elevations. Also, ecosystem impacts of contaminants contained in air masses and deposition have not been evaluated. WACAP will look at land and lake surfaces and will start with the snow coming into higher elevation systems that brings contaminants. In addition, WACAP will look at lake sediments, fish, lake water, conifer needles, lichens, etc. Contaminants of concern include some persistent organic pollutants, soil organic concentrations, and metals.

WACAP includes eight National Parks as primary sites and 12 National Parks as secondary sites; these are located in Montana, Wyoming, Colorado, New Mexico, Texas, California, Oregon, Washington, and

Alaska. Pilot studies began in 2002 and field sampling in 2003. This summer is the last year of field sampling, and analyses will begin in 2006.

WACAP is a multi-agency collaborative scientific research effort involving EPA, the USGS, the National Park Service (NPS), the U.S. Forest Service, and several universities. ORD shares scientific direction and leadership and also gains solid resources to design and conduct this research. The project is very beneficial as it maximizes opportunities, capitalizes on new synergies, designs creative approaches, addresses multi-disciplinary issues, pursues excellence, builds trust and awareness, and reaches environmental solutions. There are a number of cultural and legal challenges in the areas of quality assurance/quality control, peer review, publication clearance procedures, government printing requirements, publication disclaimers, funding cycles, and approvals required for activities to proceed. The collaborative effort is successful in this interdisciplinary, multi-agency setting because new opportunities are recognized, excellent people are committed to the effort, and there is flexibility and creativity, funding, and structure.

The Pursuit for Persistent Organic Pollutants in Parks

Chris Shaver, Chief of the Air Resources Division in the NPS, discussed the need to understand the presence and impacts of persistent organic pollutants in the National Parks and efforts underway to address this need. Toxic compounds pose health threats to wildlife and humans by affecting reproductive success, growth, behavior, disease, and survival. There is evidence of trans-Pacific transport of toxic, airborne contaminants. Persistent organic pollutants that are banned in the U.S. have been detected in Alaska and the Western U.S., and toxic levels have been detected in Canadian ecosystems. Accumulation is more likely to occur at high elevations and latitudes, using snow as the pathway, and bioaccumulation occurs through the food webs.

The presence of these pollutants pose a potential risk to National Park resources, but little information is available about this. National Parks contain relatively natural systems that can serve as early warning sites for the rest of the continent. Park managers want to know if toxic air pollutants are causing harm to Park resources and, if so, the mangers want to know which ones are present, where, how much, the effects, the source, and what can be done.

The NPS charted a course for action to address these concerns. The NPS did not have the personnel with the experience with toxic chemicals. As a result, the NPS held several workshops and brought in the "best of the best" to explain potential risks, effects, monitoring techniques, and suggested study methodologies. To resist unrealistic expectations, the NPS refined the study objectives to ask the following questions:

- Are contaminants present?
- If so, where are they accumulating and which ones pose a threat?
- What indicators are most useful?
- What are sources for the contaminants?

A geographic scope was identified, in addition to media for monitoring and data analysis methods.

Funding was a challenge, but capitalized on the participation of several researchers. A draft research plan, including quality assurance/quality control, was developed and underwent peer review. Sampling was diversified and involved:

- Annual snow sampling in the eight primary parks
- Fish, water, and sediment sampling in 2 to 3 of the primary parks each year

- Moose tissue sampling in Alaska parks
- Supplemental vegetation sampling in the eight primary parks plus 12 other secondary sites.

Results will be used based upon what is found—Were current or banned contaminants identified? Were influences local or global? What are the potential effects? Based on answers to these and other questions, solutions will be developed through collaboration with regulatory agencies and stakeholders.

What Makes WACAP Work? The USGS Perspective

Donald Campbell, with the USGS Colorado Water Science Center, discussed the USGS mission and how the USGS is supporting the goals and objectives of WACAP, including sampling techniques, challenges and obstacles, and benefits of interagency collaboration. The USGS serves the nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. The USGS Alpine Hydrologic Research Group, at the Colorado Water Science Center, researches the hydrology and biogeochemistry of undisturbed ecosystems. In addition, the USGS studies the effects of atmospheric deposition on acid rain and snow, excess nitrogen, mercury, and organic contaminants as well as the effects of climate on stream flow timing and magnitude, water quality, nutrient cycling, and sensitive species.

WACAP is a large study that will provide only a snapshot of information; however, the project will help Park managers determine the next steps and what types of long-term monitoring will be required. Snow at a variety of National Parks in this study will be analyzed for the following reasons:

- Determine seasonal contaminant loading, including spatial and temporal variability
- Compare to contaminant loading to that measured in other parts of the world
- Identify sources of contaminants
- Relate to historic records of contaminant accumulation in sediment cores
- Benchmark to determine factors controlling exposure of organisms to contaminants.

The USGS is a good partnering agency for this, as the USGS has a long-term interagency snow pack monitoring network for major ions, nutrients, trace metals, and 34S and 15N isotopes.

Snow sampling was conducted at the maximum elevations in spring, but collection needed to occur before melting. The team learned a lot about sampling techniques in this environment, such as hard snow pack, logistical concerns, and types of shovels. A range of conditions were encountered in the parks in conducting this sampling. For example, sites in Alaska tended to have relatively shallow snow packs, whereas snow packs in the Pacific area were extremely wet. The sampling team also faced some challenges, such as the need to dig extremely deep pits for sampling, the need to haul dozens of coolers of snow on skis, avalanche hazards, and climatic conditions.

Graphs illustrated the variation in the average concentration of mercury found in the snow pack across seven Parks and between 2003 and 2004 at the same Parks. Mercury levels in forested areas were found to be two times higher than mercury levels in adjacent open meadow areas, and data analysis is examining possible relationships between mercury and particulate carbon in snow.

There are some challenges with large, interagency agreements, such as funding mechanisms, differences in culture, competition, and personalities. However, these types of agreement can work with the right blend of people, effective communication, willingness to share and adapt to surprises, and synergy with problem solving.

What Makes WACAP Work? The Academic Perspective

Staci Simonich, Assistant Professor with Oregon State University, discussed the academic contributions to WACAP, including an overview of laboratory responsibilities, factors contributing to WACAP success, and examples of recent data analyses. An Environmental Chemistry Laboratory at Oregon State University supports WACAP in the following areas: measurement and environmental chemistry of persistent organic pollutants and other anthropogenic semi-volatile organic pollutants in snow, lake water, sediment, fish, vegetation, and moose; development and validation of new analytical methods; analysis of more than 800 samples for more than 120 analytes; quality assurance; assistance in field sampling; interpretation of data; and publication and presentation of results.

From the academic perspective, the secrets of success have been the right people at the right time, funding, freedom to innovate, quality assurance, and publications and presentations. The people are composed of a multi-disciplinary team with experienced technicians, post-doctoral researchers, and experienced undergraduate students. The research topic is synergistic and the University has had flexibility in overseeing personnel and timing. The funding has been consistent and reliable, and depends upon a low, negotiated overhead rate; in-kind contributions; and maximizing spending. Innovation has been fundamental, as new analytical methods have been developed and published; however, there is strict control over mission "creep." The Environmental Chemistry Laboratory received EPA approval of the Quality Assurance Project Plan, which included standard operating procedures and an audit of the facilities, and this effort was good training for the students and other personnel working in the laboratory. Further, this is a rich source of publications, since at least 30 WACAP presentations will be made by the end of 2005, including more than 14 international conferences; in addition, six articles have been published in top journals. Other secrets to success have included the training of students (four undergraduate students, four graduate students, and one post-doctorate), a wide range of experience levels (ages 20 to 60 years old) working together for a common goal, acquisition of both field and laboratory experience, and frequent communication among Principle Investigators, the project lead, and the NPS.

Some examples were shown of preliminary data from the 2003 snow sampling illustrating the presence and variation in levels of pesticides, such as Dacthal and Lindane, at Sequoia, Glacier, Rainier, Rocky Mountain, Noatak and Gates, and Denali National Parks. Additional graphs depicted the transfer of various pesticides through the ecosystem (i.e., from snow to lake water to fish) at Lone Pine Lake in the Rocky Mountain National Park and historical deposition patterns for pesticides, one banned in 1974 and one still in use, in the sediments of Pear Lake in the Sequoia National Park.

Academic partners should be selected wisely and great things should be expected, such as quality assurance, timeliness, innovation, and high-profile publications.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included how use of WACAP data by the NPS will depend on the findings and, at a minimum, will provide information to the public on what is happening in U.S. parks.

Spatial Analysis Tools and Applications for Environmental Assessments and Management

Following opening remarks by Luis Fernandez, with OIA, six speakers addressed the formation of an EPA work group on landscape ecology application of spatial analysis tools and the use of spatial analysis tools for landscape ecology applications, predicting wildlife populations in support of risk assessments, to streamline the screening process under NEPA, watershed management decisionmaking,

landscape assessment, and watershed modeling. An audience question and answer period followed the presentations.

Landscape Ecology and Spatial Analysis Tools Workshop

Luis Fernandez, with OIA, discussed a proposal to form a work group to share and foster ideas, maintain a platform for beta testing, share research, and serve as an overall support center. EPA personnel use or are interested in methods involving landscape ecology applications, spatial analytic tools, spatial decision support systems, simulation models, and methodologies grounded in physical geography. Currently, these personnel lack a forum that can aid in communicating with like-minded colleagues within EPA, exchanging knowledge, building on expertise already existing within EPA, finding resources that can help find relevant information quickly, and assisting in staying current on new developments outside EPA.

The goals of the Landscape Ecology and Spatial Analysis Work Group are to provide a communication forum for EPA personnel currently using or interested in landscape ecology applications, spatial tools, models etc.; provide a virtual showcase and technology transfer "trading floor" for landscape-ecology-related applications, spatial tools and models; and provide members a comprehensive and evolving set of landscape-ecology-related resources. Proposed activities include a landscape ecology communication forum that would foster monthly conference calls and semi-annual meetings to coincide with the EPA GIS work group meeting. In addition, a virtual showcase (or technology transfer trading floor) would establish a dedicated Web/QuickPlace gateway for tool showcasing, download, and database access. A site would also be provided to connect tool developers with a willing beta version testing community to speed up new tool development. Finally, the work group would have related resources, such as a member list, registry of tools and applications, virtual list of consultants, and an evolving list of relevant literature.

The next steps for implementation of this work group include establishing the group structure, setting up a web presence, establishing a first meeting date, and performing a needs analysis. September 2005 is targeted as the date to release the first version of the web site, which will be a user-based and user-driven initiative. Further information can be obtained from either Luis Fernandez or K. Bruce Jones.

Program to Assist in Tracking Critical Habitat

Nathan Schumaker, with NHEERL, discussed the purpose, objectives, and outcomes of the Program to Assist in Tracking Critical Habitat (PATCH), which is a simulation model to help EPA predict wildlife populations. Wildlife risk assessments conducted by EPA focus on the fate of individual animals exposed to pesticides, and it has become increasingly important that EPA scale these assessments to populations. This will be extremely complex because wildlife populations inhabit large, diverse landscapes that have a variety of natural stresses, and defensible risk assessments must address a range of natural and anthropogenic factors influencing wildlife population dynamics. Adequate tools are not presently available, but this project will attempt to build such a tool and make it available within EPA.

A simple example involves consideration of the impact of a pesticide on a wildlife population. The impact might vary significantly depending on whether the pesticide is applied to critical or marginal habitat; before, during, or after breeding; or during high or low productivity years. However, there are additional complicating factors. For example, other stressors may increase the effect a pesticide has on wildlife, such as displacement of ground nesters by harvesting, invasive species reducing stability, or fragmentation limiting dispersal.

The PATCH model is being developed to help the EPA Office of Pesticide Program conduct population-level wildlife risk assessments. The model includes information pertaining to the landscape condition and

other competing stressors in addition to traditional risk assessment components. The endpoint may in fact enhance assessments of sensitivity by providing a population-level risk assessment.

The PATCH model was developed in conjunction with a 2000 study in the Willamette River Basin conducted by the Pacific Northwest Ecological Research Consortium. The idea behind the study was that the population of the area was going to double by 2050 and this would subsequently cause several landscape changes. The study intended to look at the consequences of projected changes for wildlife populations. Imagery of the five different landscapes used in the model was shown, and included historic, current, and projected future conditions. Further, a bar graph was shown indicating the land use impacts on wildlife population's size and distribution as a result of the analyses in this study. The take home message is that when landscapes changes take place, the response is very different for different species. The PATCH model is fairly simple, as it only looks at habitat structure, yet it already produced a very complicated and complex result.

The Pacific Northwest Ecological Research Consortium investigation sets the stage for more complex risk assessments using pesticides because the study demonstrates how to incorporate the many effects of habitat quality, accounts for the influence of landscape structure on movement, and makes population-level dynamics an emergent property of the individual-level responses to environmental conditions. The PATCH model is being designed to capture the dynamics linking habitat quality, food supply, natural- and human-caused stresses, and the direct and indirect effects of pesticide use.

NEPAssist: Development of a Web-Based Mapping Application for Environmental Assessments

Harvey Simon, with EPA Region 2, discussed the NEPAssist tool, intended use, and plans for enhancement and expansion. NEPA requires all federal agencies to assess the environmental impacts of major projects or decisions, such as issuing permits, spending federal money, or actions that affect federal lands. In addition, NEPA requires that environmental impacts be considered in making decisions and these impacts need to be disclosed to the public. NEPAssist allows reviewers to screen proposed projects for potential environmental issues and it is a collaborative development that takes advantage of EPA information architecture, regional data, external data, and application services.

NEPAssist is an extranet tool that is password protected. A series of slides depicted various screens and user selections. The user first selects a study area by address, airport, hydrologic unit code, or latitude and longitude. Then, a mapping interface appears and has several layers that can be turned on and off; features include the ability to change the geography (i.e., location) from the mapping interface and to digitize and select a specific study area. A report is generated with several "yes" or "no" answers for NEPA-related questions. In addition, the report can be submitted to EPA for review and a Preliminary Assessment form can be generated.

NEPAssist is needed to simplify the process of screening proposed projects. The tool takes advantage of available geographic data, integrates complex buffering analysis into the reviewer's normal workflow, provides a user-friendly tool for reviewers, and allows analysis for more projects. NEPAssist benefits the EPA, as it meets the core requirement from the Office of Federal Activities for screening analysis. In addition, the buffering of critical environmental features and custom reporting function may have the potential for spinoffs to other programs, such as wetlands, emergency response, enforcement, targeting, and others.

NEPAssist is a web-based GIS tool that requires no training, desktop licensing, configuration, or desktop data. The application reaches out to different servers for various data sets. The mapping component is driven by ArcIMS and SDE programming and uses structured query language statements to form

proximity questions, which drives the queries in Oracle. The tool is distributed via web services and uses consistent data sets. The tool was piloted in EPA Region 2, and EPA Regions 3 and 5 also are planning roll-outs. Planned enhancements include more image backdrop options, choices of map window size, reviewer page upgrades, nationally available data layers, hyperlinks to background information and metadata, and navigation improvements. The success of the tool, including nationwide access and data, requires lots of coordination between various organizations.

Web-Based Decision Tools for Watershed Management

Richard Zdanowicz, with EPA Region 5, and Dreux Watermolen, with the Wisconsin Department of Natural Resources, discussed the tools developed by the Midwest Spatial Decision Support System Partnership, the history of the Partnership, and requirements for future success. The Midwest Spatial Decision Support System Partnership offers state and local decisionmakers 13 regional decision support tools (available at http://www.epa.gov/waterspace). The tools have bundled data and are a means of providing clear impact analysis. The tools are focused at the community level, as smaller communities do not have the capabilities to do complex environmental assessments. The tools represent a means of bringing together scientific information, screening for alternatives, and subsequently writing, evaluating, and adjusting community plans if necessary.

"*What happens on the land will affect the quality of the water in the waterways*." An example involved Grundy County, Illinois, in which changes to average annual runoff were examined for two different scenarios for conversion of farmland to commercial and other uses; this example showed significant increases in run-off volume for the scenario with a larger acreage converted.

The Partnership is also working diligently in Wisconsin where 84 percent of the land is owned by private parties, and local governments have primary responsibility for regulating land uses. In Wisconsin and other areas of the country, private landowners make land use decisions that affect the environment. Citizens are forming partnerships, but none have the full information required to assess the impacts of their decisions. Environmental agencies cannot manage and protect all natural resources or every aspect of the information; however, citizens and local officials are powerful allies in resource stewardship and environmental protection. Science can be brought to their decisions, which is the driving motive behind the creation of the Midwest Spatial Decision Support System Partnership. The decision support tools provided by the Partnership can help people find and access data, make maps through ArcIMS applications, and model potential impacts.

The Partnership was developed in April 2002 and current members include the Indiana Department of Environmental Management; International City/County Management Association; Michigan State University, Institute of Water Research; Purdue University (Agricultural and Biological Engineering, Forestry and Natural Resources); State University of New York at Buffalo; University of Wisconsin-Extension; EPA Region 5 Office of Public Affairs, Water Division, and Office of Information Services; Wisconsin Department of Natural Resources; EPA Headquarters Office of Water Smart Growth Team; and NERL in EPA.

The purpose of the Partnership is to develop and promote the use of web-based, user-friendly, geospatial watershed management data and decision support tools. In addition, the Partnership wants to help set the standard for other watershed management programs by promoting data initiatives, relating specific tools to planning process phases and learning objectives, and creating systems where outputs of the tools can be used in other models. The Partnership has achieved several accomplishments, such as bringing together tool developers, resource managers, and decisionmakers from all levels of government. The tools are drawing attention and increased commitment from other parties, in addition to extending community outreach activities.

The Partnership is sponsoring certain decision support tools and data initiatives to serve the needs of local decisionmakers and is expanding outreach activities and partnerships to reach others who serve the needs of local communities. In addition, the Partnership is providing direct feedback from decisionmakers to tool developers and exerting leadership, both regionally and nationally, to advance efforts. Federal, state, and local government partnerships have also been formed to promote decision support tools for watershed management and land use decisionmaking.

Analytical Tool Interface for Landscape Assessments

Donald Ebert, with NERL, discussed the history, architecture, benefits, and future plans of the Analytical Tool Interface for Landscape Assessments (ATtILA). Landscape ecology is an interdisciplinary science framework that studies the relationship between spatial patterns of the landscape conditions and risks to ecological resources, such as forests, rangelands, wetlands, rivers, streams, lakes, and urban environmental settings. A simple landscape model looks at changes in the landscape, ecological goods and services, composition and pattern, and hydrological processes.

In order to analyze the landscape, several data layers are needed including elevation, land cover, stream networks, road networks, census data, soil data, and geology data. Spatial patterns can be analyzed, such as riparian agriculture, riparian forest, forest fragmentation, road density, forest land cover, agricultural land cover, agriculture on steep slopes, potential soil loss, roads near streams, slope gradient, slope gradient range, urban land cover, wetland land cover, barren land cover, population density, population change, and impervious land cover. The fundamental question is whether measurable aspects of landscape patterns can be related to observed conditions in ecological resources.

A request was made for a landscape assessment tool that would provide an easy-to-use ArcView graphical user interface environment for landscape assessments, require little to no pre-processing of input data, include the most common landscape and watershed metrics with emphasis on water quality influences, be scale independent (e.g., for use with satellite or other remote sensing data), allow flexibility by giving the user a wide choice of data sets, and provide a means for quick assessment of results. The tool also needed to be expandable for additional landscape metrics, data sets, and analyses as needed.

A series of slides illustrated the tool and its use through screen captures. ATtILA has met the requested needs of the intended users, and includes a graphical user interface, friendly menus, help menus, selectable metrics, a wide choice of data sets, class summaries and cut-off values, and land cover classification systems. Landscape characteristics provided through use of this tool include land cover percentages in watersheds, diversity of land cover, amount of agriculture on steep slopes, forest patch statistics, patch edge/area measures, and land cover fragmentation measures. Riparian characteristics include land cover percentages in areas adjacent to streams and adjacent to sample points. In addition, human stressors include nutrient loading estimates, impervious surface estimates based on land use and land cover, impervious surface estimates based on road density, population density and change, road density measures, stream and road crossings, and road area adjacent to streams. ATtILA provides results quickly and the results can be viewed in atlases, indices, column graphs, and other formats. In addition, ATtILA can combine multiple metrics into a single value.

In addition to assessing changes in landscape, ATtILA can be used for water quality assessments, reference and sample site targeting, critical are mapping, and teaching. It allows for non-GIS professionals to conduct complex analyses, speeds analyses for both experienced and inexperienced GIS users, eliminates many potential errors, and allows for easy repeatability and experimentation.

Currently, ATtILA is used by several federal, state, and local agencies. In the future, ATtILA will be ported to Visual Basic code to be used with Arc9 applications and will be incorporated into the EPA tool for Better Assessment Science Integrating Point and Nonpoint Sources (BASINS).

Automated Geospatial Watershed Assessment

David Goodrich, with the Southwest Watershed Research Center in this USDA Agriculture Research Service, discussed the Automated Geospatial Watershed Assessment (AGWA) tool and its applications. AGWA is a PC-based GIS tool for watershed modeling that investigates the impacts of land use and land cover change on runoff, erosion, and water quality at multiple scales. AGWA uses basic, commonly available GIS data along with a simple, direct method for model parameterization. AGWA is useful for scenario development and alternative future simulation work, and is targeted for use by research scientists and management specialists.

AGWA uses two models for multi-scale assessment of landscape change. The watershed must first be delineated using a Digital Elevation Model; then, other elements (such as soil, land cover, and precipitation) are integrated prior to running the model. At that time, either the Kinematic Runoff and Erosion (KINEROS) model or the Soil and Water Assessment Tool (SWAT) model can be executed and imported for the study site.

AGWA has been used in the Upper San Pedro River Basin to assess land cover change and the impact on hydrologic resources. The SWAT model was run to assess the Basin at a large scale; however, if the user wants to look at a smaller scale, the KINEROS model can be run. An image was shown depicting AGWA results, which illustrated the changes in land cover type and water yield in response to increased population.

In conjunction with performing assessments and running models, AGWA enables users to build and test management scenarios. Locations of land cover alterations can be specified by either drawing a polygon on the display or by specifying a polygon map. A user-defined land cover can be applied to a specific area, land cover types can be changed from one area to another, land cover can be implemented with a user-supplied polygon map, or random land cover (e.g., a simulated burn pattern) can be defined.

AGWA can be used for engineering design, planning, or identifying potentially impaired TMDL areas. AGWA can also be incorporated with ATtILA by exploiting the landscape characterization functionality of ATtILA, which improves parameterization of the SWAT model in AGWA. Further, ATtILA can incorporate outputs, such as sediment yield, from AGWA and places them into the landscape metric assessments.

AGWA 1.1 was released in July 2002 and was added to the ORD Council for Regulatory Environmental Modeling in January 2004. AGWA 1.4 was released in July 2004 and was exhibited as a TMDL tool at the 2004 EPA *Science Forum*. AGWA was integrated into the BASINS 3.1 release in August 2004. Currently, there are 850 registered users. A detailed, peer reviewed design plan was completed in April 2005, which is compatible with plans for BASINS and ATtILA. More information is available at: http://www.epa.gov/nerlesd1/land-sci/agwa and http://www.tucson.ars.ag.gov/agwa.

Questions and Answers

The speaker had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) the desire for greater interoperability and connectivity of PATCH and other models; (2) consideration of general distributed database structures to capture the inputs needed to parameterize a model such as PATCH, and potential

use in creating a template for a larger effort; (3) the desire to build a model that does not have more complexity than is necessary and efforts to design PATCH to do as much as possible with as little data as possible; (4) how the quantity of data translate into more/less complexity in results and the need to find the optimum balance of data, robustness of results, outcome sophistication, and uncertainty; (5) the need for feedback to those working on the EPA Research and Science Architecture about these types of considerations and product/tool needs; (6) the challenges with incorporating cumulative impact considerations into NEPAssist given the lack of historical data for these projects and the hope that populating NEPAssist with current projects will, in the future, provide the ability to do such analyses; (7) the need to go to a project area to download the data of interest in ATtILA and how ATtILA is not set up to serve data; (8) the availability of test data sets and training exercises to enable potential users to determine if ATtILA will meet their needs; and (9) the expense incurred in moving to ARC-GIS that small municipalities and others cannot pay and the hope that web-based tools discussed in this session will provide the necessary access.

Sustainable Solutions for Restoring Degraded Watersheds and Riparian Ecosystems: Implementation, Evaluation, and Amelioration

Following opening remarks by Joseph Williams, with NRMRL, five speakers addressed the EPA ecosystem restoration research framework, a GIS-based decision tool for watershed restoration planning, modeling stream and riparian ecosystem restoration, challenges of stream restoration in increasingly developed areas, and water quality improvements through urban stream restoration. An audience question and answer period followed the presentations.

EPA Ecosystem Restoration Research

Joseph Williams, Chief of the Ecosystem and Subsurface Protection Branch in NRMRL, discussed the EPA framework for ecosystem restoration research and EPA interactions with other agencies and organizations. The Groundwater and Ecosystem Restoration Division in NRMRL conducts laboratory and field research to provide the scientific basis to support the development of strategies and technologies to protect and restore ground and surface water quality within a watershed perspective. The mission of the EPA Ecological Research Program is to protect, sustain, and restore the health of natural habitats and ecosystems. Thus, the Ecological Research Program conducts research to strengthen EPA's ability to assess and compare risks to ecosystems, to protect and restore ecosystems, and to track progress in terms of ecological outcomes.

The EPA framework for ecological restoration includes programs such as Restoration Plus, EMAP, and Regional Vulnerability Assessment. Ecological restoration research examines the physical, biological, and chemical processes that impact restorative actions; researches decision support tools to evaluate restoration and management alternatives; and develops protocols for measuring and predicting restoration effectiveness. This type of research is accomplished in collaboration with academic institutions, state and local governments, NGOs, federal agencies, and EPA regional and program offices.

Highlands Action Program

Jennifer Newland, with the Canaan Valley Institute, discussed research efforts and goals of the Highlands Action Program and the framework behind a spatial multicriteria tool. The Canaan Valley Institute is an organization that serves the Mid-Atlantic Highlands and builds infrastructure for change by working with local communities and associated groups to help them come together and solve problems. The Canaan Valley Institute helps communities visualize and reach desired changes, such as cleanable water, stable stream banks, more fishing days, and more livable communities, and tries to find a balance between science and stakeholders to find a sustainable solution through local empowerment, facilitation and capacity building, and information and technology transfer.

The Highlands Action Program is being created to bring resources for action through a cooperative initiative in which states and local communities have a serious role and outcomes are the leading measures of success. The goal is sustainability achievable through environmental, economy, and equity that is realized through policymaking, planning, assessment, and local actions. The Canaan Valley Institute relies on EPA research and examples of collaborative efforts include Highlands Action Program report science content, economic valuations and energy, alternative futures and fish population modeling, and indicators and thresholds for prioritization.

Restoration impacts must be understood, and this is accomplished through planning conferences to explore the economics of ecological restoration and the research connections between environmental and economic conditions. In addition, the Highlands Action Program draws on prioritization tools to establish a prioritization framework, a template for watershed restoration planning, and watershed level optimization for project selection. The short-term prioritization goal is to use information and maps to secure significant resources for implementation. The medium-term prioritization goal is to provide a flexible tool for Highlands Action Program managers. The long-term prioritization goal is to help local groups and decisionmakers prioritize the projects.

The Highlands Action Program is utilizing a GIS framework for multi-criteria decisionmaking. In this framework, the GIS is used to automate, manage, and analyze spatial data; data sets and derived layers can be weighted. Derived layers fall into a variety of categories, including biophysical condition and vulnerability with respect to thresholds, land use change risk, green infrastructure, social resources, and economic indicators of natural resource dependence. There is also a Multicriteria Decisionmaking Model that offers techniques and procedures to frame the process and reveal decisionmaker's preferences. Together these components provide for spatial multi-criteria analysis.

This tool has been tested on headwater watersheds, and uses watershed-based and landscape-based weightings. The tool is the beginning of fine scale optimization, which was illustrated with a local county example. The results of this analysis indicated the need to re-write their comprehensive plan.

Restoring Great Basin Riparian Ecosystems

Jeanne Chambers, with the U.S. Forest Service, discussed an interdisciplinary effort with EPA to restore a riparian ecosystem. The study site is located in central Nevada at approximately 10,000 to 11,000 feet in elevation, and is comprised of broad, alluvial valleys in a cold, desert ecosystem. Water in the semi-arid region is very critical. The riparian areas involve only 1 to 2 percent of the land area, yet account for most of the biodiversity in the region. Stream systems range from 9 to 12 kilometers in length and often consist of high gradient streams with low stream flow. During the last half of the 20th century, the valley has seen an incision of almost 20 feet. The stream has changed from the original flood plain, water tables have decreased, and more xerophytic vegetation has grown.

The recent problem in this region is the loss of key riparian ecosystems. The Rocky Mountain Research Station initiated the Great Basin Ecosystem Management Project in 1993 to address problems associated with stream incision and riparian area degradation. The goals of the project are aligned with the mission of EPA and include the following:

- Understand basic ecosystem processes controlling stream systems and riparian areas
- Determine the environmental and anthropogenic factors driving the changes
- Develop and communicate methods for restoring and maintaining sustainable ecosystems.

Restoration implications are examined, which builds on existing data to define interactions between the geomorphic, hydrologic, and biotic processes operating along the riparian corridor. This information will be used to develop a system for prioritizing meadow restoration efforts, develop appropriate restoration approaches, and evaluate restoration outcomes.

The project has several stakeholders and collaborators, such as EPA, Bureau of Land Management, U.S. Fish and Wildlife Service, USGS, Humboldt-Toiyabe National Forest, farmers, ranchers, and several universities. The interactive model for this effort includes stakeholders, management, and research, and will involve a process-based approach between geomorphology, biotic interactions, and hydrology at various spatial and temporal scales. It will be essential to understand stream and riparian ecosystem processes, effects of anthropogenic disturbances, and basin sensitivity.

Watersheds vary in sensitivity to disturbance, and sensitivity reflects the magnitude and type of channel change in response to external factors. In modeling the basin sensitivity, four groups were designated: flood dominated, deeply incised channels, fan dominated, and pseudo-stable channels. Geology, geomorphic characteristics, and vegetation types were taken into account to define an overall sensitivity rating for each group.

The conceptual basis for management and restoration was utilized is that many streams and riparian ecosystems are functioning as non-equilibrium systems. Therefore, incision will continue due to sediment limitation, and the rate and magnitude of incision is increased by anthropogenic disturbance. In addition, watersheds vary in their sensitivity to disturbance—some streams have adjusted to the current geomorphic conditions and others are still adjusting. Returning to the pre-disturbance state following incision is an unrealistic goal for both streams and riparian ecosystems; however, managing for sustainability is still a valid goal.

This research utilized a process-based restoration approach that drew on the understanding of basin sensitivity and geomorphic processes to develop a system for prioritizing meadow restoration efforts. In addition, methods were developed for increasing stability of valley segments and stream reaches currently incising or at risk of incision.

Importance of EPA Ecosystem Research to Environmental Management Programs in Baltimore County, Maryland

Donald Outen, the Natural Resource Manager for the Baltimore County Department of Environmental Protection and Resource Management, discussed county-level initiatives in ecosystem research, the need for collaborative research, use of EPA research, and case studies from Baltimore County environmental programs. EPA ecosystem research is important to local governments and Baltimore County has had a good experience working with federal agencies to develop quality research.

Baltimore County is the third largest county in Maryland with an estimated population of 780,000 within 610 square miles. There are no incorporated municipalities; therefore, Baltimore County is the only unit of local government. Land cover types and resources in the County include the following: 82 percent Piedmont Province; 18 percent Coastal Plain; one-third urban, agriculture, and forest land cover; greater than 220 miles of Chesapeake Bay shoreline; and more than 2,100 miles of freshwater streams and tidal rivers. In addition, Baltimore County encompasses 63 percent of three city-owned reservoir watersheds and 50 percent of the streams that drain to reservoirs.

More than three-fourths of the population growth came in a 30 year period between 1940 and 1970, and most of the population growth occurred in the 1950s. The local governments were not equipped to deal with the rapid growth, but growth boundaries, zoning alternatives, and environmental elements were

ultimately implemented into master planning. Currently, 90 percent of the population lives within a defined urban growth boundary.

Resource Conservation Zones were first established in 1975 to protect reservoirs and low-density development. Citizen support was critical to the success. Resource Conservation Zones are still modified today and are designated to reduce forest fragmentation, assist in management policies, etc.

Development patterns before environmental regulations were implemented utilized a minimum lot size zoning approach, used engineering to overcome site limitations, and did not provide for storm water management or protection of streams, wetlands, or forests; 87 percent of the County's population arrived in this period (prior to 1980). Post-regulatory development patterns use density zoning to protect streams, wetlands, and forests and site-based environmental assessment and regulations and storm water management guidelines are implemented.

A key challenge is that the cumulative effect of human disturbances is threatening the sustainability of the natural environment; consequences for this include loss of ecosystem services and socio-economic values. In addition, federal and state mandates now require local governments to address deleterious management practices including impacts of historic land use change, and local governments have traditionally not understood and have not been adequately prepared to use science-based management; restoration is expensive and practitioners need to justify projects to elected officials.

In response to these challenges, Baltimore County has implemented an Integrated Watershed Management Program that works with the local communities, federal agencies, and respective policy drivers. Stream restoration objectives include:

- Re-establishing equilibrium channel pattern, profile, and cross-section
- Conveying base flows, bank-full flows, and flood flows
- Reducing stream bank erosion and channel incision
- Improving water quality and controlling storm water
- Providing in-stream and riparian habitat
- Protecting in-stream infrastructure (e.g., sewers, bridges, and culverts)
- Protecting private property and structures
- Improving community aesthetics.

As of 2003, 700 stream miles (one-third of all streams) have been assessed for geomorphic stability, 42 projects have been completed, 80,100 feet have been restored, and $22.9 million has been invested. A series of slides illustrated the pre- and post-restoration condition of several project sites.

Improving Water Quality through Urban Stream Restoration at Minebank Run, Towson, Maryland

Paul Mayer, with NRMRL, discussed the impacts of stream restoration projects on water quality and a case study involving restoration of Minebank Run in Towson County, Maryland. There are many river and stream restoration projects underway in the U.S., for a variety of objectives, and involve investments of billions of dollars. Urban stream degradation results in removal of the riparian zone, bank incision, reduced fish habitat, sediment inputs, nutrient inputs, and lateral movement of the stream channel, as demonstrated by a photograph of Minebank Run. Restoration is very complicated and sophisticated, and various techniques must be used, such as bank reshaping, revegetation, channel manipulation, substrate manipulation, and erosion control. The primary objective of stream restoration is to improve geomorphic stability, which will hopefully improve water quality. Projects need to be monitored to assess whether or not improvement occurs.

The Minebank Run project is very interdisciplinary and involves participation by multiple agencies with overlapping responsibilities:

- EPA (hydrology and biochemistry)
- USGS (geology, sediments, and biochemistry)
- Institute of Ecosystem Studies (denitrification)
- Baltimore County Department of Environmental Protection and Resource Management (restoration and biota).

An aerial photograph delineated the watershed showing the Minebank Run, headwaters to the west, and the two study sites (one in the upstream and one in the downstream). On-ground photographs depicted the stream before restoration and showed that the stream suffered from urban stream syndrome, which includes mass wasting, sloughing, lateral movement, exposed sewer line, and bank erosion. Both pre- and post-restoration monitoring is being conducted, and groundwater monitoring wells were used to examine the subsurface and water table levels.

A research question was how stream restoration might contribute to removal of nitrogen in the form of nitrate. Denitrification in the natural environment is a microbial process that requires anaerobic conditions and organic carbon. Hydraulic changes can produce anaerobic conditions, transport of organic material can supply carbon, and floodplain reconnection allows the carbon and nitrate to mix. Graphs of bioreactive nitrogen in restored and unrestored areas demonstrated that restoration has some effect on biogeochemistry of the stream, and preliminary data indicate that higher rates of denitrification occur in the restored reaches.

Not all of Minebank Run has been restored, and those efforts will result in additional data. However, preliminary findings are that restoration techniques may reconnect the floodplain and enhance denitrification. Reshaping of the stream banks is anticipated to enable the floodplain to reconnect and the saturation zones to merge.

Minebank Run represents a project where researchers are trying to understand how restoration can be a sustainable method for improving water quality. Other agencies are looking to obtain this information to assess the effects of stream restoration on water quality. Based on these data, stream restoration should be adopted as a method to improve water quality.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) plans for future incorporation of eMergy messages into the spatial multicriteria tool being developed by the Canaan Valley Institute; (2) variations in response by local decisionmakers and communities throughout the Highlands County of economic growth, with some embracing tourism and others not; (3) the difficulty in obtaining funds for ecosystem restoration and efforts to identify alternative funding sources as well as understanding the criteria important to private investors; (4) how much of the literature on the effects of livestock grazing do not demonstrate an understanding of how the ecosystems worked and did not quantify the characteristics of the affected ecosystems; (5) how efforts to restore the Great Basin riparian system are focused first on understanding how the ecosystems were functioning in order to have a strong basis to move forward and develop the restoration approaches; (6) the availability of ecosystem restoration project descriptions at http://cfpub.epa.gov/surf/locate/map2.cfm; (7) how quickly elected officials in Baltimore County embraced ecosystem restoration and how this was the result of clear

information on the nature of the problem, aggressive pursuit by the County agency, and (8) citizen requests to address stream erosion.

The Environmental Technology Verification Program: Collaborating for Outcomes

Following opening remarks by Teresa Harten, with NRMRL, five speakers addressed the overall ETV program and example research activities on diesel engine retrofit technologies to reduce emissions, field testing of ambient ammonia monitors, treatment systems to remove arsenic from drinking water, and ballast water treatment technologies. An audience question and answer period followed the presentations.

Environmental Technology Verification Program Update

Teresa Harten, with NRMRL, introduced the ETV Program and its role in conducting research to solve important environmental problems. The objectives of the ETV Program are to provide credible performance information for commercially-ready technology to help solve high risk environmental problems and to aid industry and other organizations in making decisions to purchase innovative technologies, policymakers and regulators in making policymaking and permitting decisions about innovative technologies, and vendors/developers in selling and further developing innovative technologies. ETV helps with technology commercialization and innovation through a process involving research, proof of concept, development, demonstration, and verification, which all leads to commercialization and development.

The ETV Program has had many successes including 317 verifications and 82 protocols. In addition, the ETV Program has seen increased funding from vendors, increased stakeholder participation, and increased web and international interest. The ETV Program primarily supports solving important environmental problems, and also has played an important role in homeland security verifications.

As of 2005, there are six ETV centers. Two of the centers receive continued partial EPA funding as well as full quality assurance and technical support into the future: the ETV Air Pollution Control Technology Center and the ETV Advanced Monitoring Systems Center. Four centers receive full EPA quality assurance and technical support and seek full funding from vendors and others: the ETV Drinking Water Systems Center, the ETV Greenhouse Gas Technology Center, the ETV Water Quality Protection Center, and the ETV P2 Coatings and Coating Equipment Center.

To ensure that the top priorities of EPA remain funded and verified, the ETV Program developed an Environmental and Sustainable Technology Evaluation (ESTE) that targets high risk Agency needs and is scoped to include all environmental technologies except those covered by the Superfund Innovative Technology Evaluation Program. EPA initiates and directly manages all ESTE verifications and is seeking cost sharing and collaboration opportunities. A goal is to kick off a pilot project in 2005.

The ETV verification process begins with establishing verification and identifying technology categories. EPA works with stakeholders to identify vendors and collaborators, prepare test plans and quality assurance plans, conduct the verification testing, and write the verification report. In the period of 1995 through 2004, the ETV Program conducted 299 verifications for the following technology categories: monitoring (142), air (75), water (58), pollution prevention (21), and building decontamination (3).

The outcome of the ETV Program is improved health and environmental quality, and this is driven by the outputs, which are the large number of protocols and verifications. These outputs provide valuable information to potential buyers, regulators, and vendors; support the use of better technologies to reduce

emissions or provide other benefits; and support reduced exposure, resulting in reduced risk to health and environmental quality. More information on the ETV Program is available at http://www.epa.gov/etv.

Diesel Engine Retrofit Technologies

Evelyn Hartzell, with NRMRL, discussed issues associated with diesel-powered vehicle engines, and verification activities for diesel retrofit technologies to reduce emissions. There are 7.9 million heavy-duty trucks and buses in the U.S. that use diesel fuel and emit large amounts of PM, hydrocarbons, and NOx. These emissions contribute to serious public health and environmental problems, including premature mortality, asthma aggravation, and reduced visibility, among others. Several areas of the country are currently considered to be in nonattainment of the NAAQS under the CAA. Trucking enterprises account for 30 percent of transportation-related PM emissions in the U.S, and school buses are also a significant source of diesel emissions; 24 million children ride a bus to and from school each day, and children are especially susceptible to the pollutant emitted from the use diesel fuel.

There is increasing recognition of the importance of diesel engine emissions, and this partly resulted from the development of regulations designed to reduce emissions from new diesel engines. In addition, voluntary programs designed to encourage the use of retrofit technologies and other emission-reducing alternatives, such as the Voluntary Diesel Retrofit Program, have been implemented. The use of emission reduction credits from State Implementation Plan in areas that are not in compliance with NAAQS limits and the development of a several innovate technologies for retrofit diesel have also encouraged the recognition of diesel emission concerns.

With input from several organizations, the ETV Program responded to these concerns by developing three diesel engine retrofit protocols and verified seven diesel retrofit technologies in 2004. The protocols addressed alternative fuels, additives, and lubricants; selective catalytic reduction; and exhaust catalysts, filters, and engine modifications, and these protocols are available at the ETV web site. Test results from the diesel retrofit technology verifications indicated the technologies primarily reduced PM; hydrocarbons and carbon monoxide were also reduced, but to a lesser extent. Potential impacts of implementing this technology, assuming a 10 percent market penetration, would be reductions in PM emissions by 8,980 to 31,300 tons after 7 years.

Dennis Johnson, with the Office of Transportation and Air Quality, discussed the National Clean Diesel Campaign and its mission to control mobile sources of air pollution. EPA has taken aggressive action to set stringent standards for new diesel engines and initiated voluntary measures reduce emissions from existing engines. Given the importance of controlling diesel emissions in a comprehensive and integrated manner, to protect health and to allow nonattainment areas to meet NAAQS, EPA is consolidating diesel clean-up efforts under the National Clean Diesel Campaign.

The regulatory component for new engines takes a systems approach to address requirements for engine emissions and fuel. Proposed reductions in sulfur in diesel fuel have benefits for voluntary programs for existing engines as well, such as reducing maintenance costs, generating significant sulfate PM reductions, and enabling retrofit with post-treatment technologies. The voluntary programs have a goal to reduce emissions by 2014 from the 11 million legacy engines. The voluntary programs are sector-specific with a geographic emphasis where appropriate (e.g., nonattainment area, rural, urban, susceptible populations). The five targeted sectors are school buses, ports, construction, freight, and agriculture.

Various types of diesel retrofit technologies and mobile source technologies are being considered, including:

- Devices such as diesel exhaust catalysts, PM filters, and engine modifications

- Fuels such as alternative fuels, reformulations, fuel additives, lubricants, and lubricant additives
- Select catalytic reduction.

The test approach is based on the Federal Test Procedure for engine dynamometer tests with a minimum of one cold start and three hot starts. Results are reported as a mean with a confidence interval of 95 percent of emission reduction for each pollutant. In the testing approach, emissions reductions from engine certification level, de-greened, and aged technologies are reported for each engine type; multiple engine testing will also be conducted. For the verification process, the manufacturer would submit an application and the verification team would discuss the application, test plan, and quality assurance plan. Upon EPA approval of the test plan and the quality assurance plan, the applicant signs a contract with the ETV Air Pollution Control and Technology Center, which conducts the verification tests and publishes a report.

Ambient Ammonia Monitors

Thomas Kelly, with Battelle, discussed ammonia emissions, the formation of fine PM, and ammonia monitor testing and results. Ammonia emissions to the air contribute to the formation of fine particles (PM2.5) that result in human health effects through inhalation and reduce visibility (i.e., regional haze). In addition, ammonia emissions result in the deposition of ammonia gas and particles to surface waters, and this potentially can result in eutrophication of surface water, fish kills, and reduced biodiversity. Animal feeding operations are estimated to be the largest single U.S. source of ammonia emissions at approximately 65 percent, or 2,200,000 metric tons each year, as ammonia is emitted from animal feeding operations by microbial decomposition of animal waste.

State regulation of ammonia emissions from animal feeding operations is increasing and has an emphasis on concentrated animal feeding operations. The Consolidated Emissions Reporting Rule requires states to report point source ammonia emissions. However, uncertainty exists about the applicability of federal requirements under the CAA, Comprehensive Environmental Response, Compensation, and Liability Act, and Emergency Planning and Community Right-to-Know Act to concentrated animal feeding operations. Further, the National Academy of Science has called for improved ammonia measurements in order to improve ammonia emission estimates.

The ETV Program has responded by collaborating with the USDA to field test commercial ammonia monitoring instruments at concentrated animal feeding operations. The USDA National Soil Tilth Laboratory in Ames, Iowa, has arranged field sites, supported test planning, and collaborated in field test activities, with the testing led by Battelle. Phase I was completed from September to October 2003 at swine finishing farms in Ames, Iowa. Phase II was completed from October to November 2003 at cattle feed lots in Carroll, Iowa. Testing involved ammonia monitors from seven vendors and the following analytical techniques:

- Tunable diode laser absorption spectroscopy
- Open path Fourier transform infrared absorption spectroscopy
- Ion mobility spectrometry
- Photoacoustic infrared absorption spectroscopy
- Selective membrane permeation with conductivity detection
- Catalytic oxidation and chemiluminescence.

Tables and graphs illustrated the comparability of the results with the reference method for each monitor tested.

EPA expects to select 28 concentrated animal feeding operations for a 2-year monitoring study under a voluntary Air Quality Compliance Agreement with the animal producers. The ammonia monitoring protocol specifies the use of chemiluminescence, photoacoustic infrared absorption spectroscopy, open path Fourier transform infrared absorption spectroscopy, or an ultraviolet method depending on the facility. ETV test results may be relevant to selection of ammonia measurement methods for this study.

Adoption of ammonia monitoring technologies by concentrated animal feeding operations could have a large market impact. The background document for the effluent guidelines for concentrated animal feeding operations estimated that there are about 15,000 large and medium concentrated animal feeding operations. Monitoring may be needed at numerous concentrated animal feeding operations to address state and federal regulations. The potential benefits of ammonia monitoring at concentrated animal feeding operations include improving emission estimates, assessing the need for emission reduction measures, assessing the effectiveness of emission reduction measures, and decreasing emissions with consequent environmental and health improvements estimated at over $4 billion annually.

The ETV and USDA collaboration is continuing for testing of hydrogen sulfide monitors at concentrated animal feeding operations. The issues in that study involve worker exposure to hydrogen sulfide, odor, and air emissions.

The ETV reports on the ammonia monitor testing are available at:
http://www.epa.gov/etv/verifications/vcenter1-30.html.

Arsenic Drinking Water Treatment Systems

Bruce Bartley, with NSF International, discussed current arsenic research at the ETV Drinking Water Systems Center, the importance of state support, and testing procedures. The Drinking Water Systems Center began in October 1995 with a focus on small system technology needs. Protocols provide for uniform testing and quality control procedures. Testing is primarily performed in the field, but state collaboration is necessary for acceptance and support. The next phase is private sector and non-EPA financial support.

State support is critical, as the states must ensure that regulations are actually carried out. The Association of State Drinking Water Administrators (ASDWA) is involved and supports the ETV Drinking Water Systems Center. Annual state surveys have shown increasing ASDWA member support. States review protocols, test plans, and reports in order to provide input and suggested improvements. In addition, states use the ETV reports in approving alternative technologies.

Stakeholders collaborate on pre-test protocols in areas such as research, writing, technical review, quality assurance, and recommendations. EPA and NSF independently conduct a quality assurance review of a proposed protocol and consider its use in ETV testing. After a protocol is used in an ETV test, stakeholder feedback is the basis for modifications and improvements to the protocol.

Collaborative efforts are currently underway in the States of Utah, Pennsylvania, Alaska, and Michigan. Arsenic removal technologies undergoing testing at the ETV Drinking Water Systems Center include chemical coagulation with filtration, reverse osmosis, and adsorption (via ion exchange or via disposable or regenerable media). Test results show that all but one technology consistently reduced arsenic to below the Maximum Contaminant Level of 10 ppb. In addition, most of the technologies achieved arsenic reductions to the reportable detection limit of approximately 2 ppb. Preliminary test results from other technologies undergoing testing show similar trends. Performance is greatly influenced by water quality and process parameters.

Jeff Adams, with NRMRL, discussed the impacts and outcomes of the arsenic removal technology testing and research. The ETV Program provides information to help states, utilities, and other organizations select appropriate water treatment technologies to meet the new 10 ppb arsenic regulatory standard. Many of the ETV-verified technologies demonstrated the capability to reduce arsenic levels in drinking water to 5 ppb or less. This provides several available off-the-shelf technology alternative for the estimated 4,100 drinking water systems anticipated to be required to install treatment to meet the new arsenic standard.

Arsenic in drinking water is a known carcinogen with additional adverse human health impacts. EPA estimated the health benefits of arsenic reduction in the economic analysis for the arsenic drinking water rule (EPA 815-R-00-026). The estimated 100% potential market for ETV technologies includes the 3,900 smaller community systems affecting about 4.4 million people. Economic benefits of lung and bladder cancer prevention by ETV-verified arsenic removal technologies have been estimated for different market penetration scenarios, and range from $4.8 to $17.1 million.

State agencies have indicated that the ETV studies in this area may help to minimize pilot testing requirements and to expedite the approval and implementation of arsenic treatment technologies. Also, ETV results provide technology vendors with valuable data on product weaknesses that may be addressed in subsequent product modifications.

Ballast Water Treatment Technology Verification through an Interagency/Private Partnership

Ray Frederick, with NRMRL, discussed the collaboration to develop the Ballast Water Treatment Protocol and associated research efforts. Development of the Ballast Water Treatment Protocol involved collaboration between the EPA ETV Program, the U.S. Coast Guard Environmental Standards Division, a Naval Research Laboratory, NSF International, Battelle, a stakeholder advisory group, a Technology Panel, and a Biological Support Group. In June 2001, efforts began between the ETV Program and the U.S. Coast Guard to develop a stakeholder advisory group to provide general guidance and direction, and a technology panel to provide technology specific guidance and assistance in developing verification factors.

A working draft of the Ballast Water Treatment Protocol was formulated in 2004. A biological support group was established to determine surrogate organism selection, large-scale culturing requirements, and measurement methods. Research was initiated to determine the most appropriate surrogates; the candidates will be exposed to representative treatment technologies in 2006. The U.S. Coast Guard is collaborating with the Naval Research Laboratory in Key West, Florida to develop a full-scale technology testing facility to be completed by late 2005 and this facility will be used to pilot test the protocol. The protocol will be revised to include information from pilot tests and surrogates in March 2006 with vendor testing anticipated to be initiated in mid-2006.

Kathleen Moore, Commander, U.S. Coast Guard, discussed the needs driving the development of the Ballast Water Treatment Protocol and ballast water treatment research. The zebra mussel epidemic in the Great Lakes in 1988 prompted Congress to issue the 1990 Non-Indigenous Aquatic Nuisance Prevention and Control Act, which was later followed by the National Invasive Species Act of 1996. Under these and other state/federal laws, all vessels entering a U.S. Exclusive Economic Zone are subject to mandatory requirements regarding ballast water management records, ballast water exchanges at least 50 miles from shore, and ballast water treatment using only those systems with U.S. Coast Guard approval.

The rulemaking required that a ballast water discharge standard be developed that is scientifically sound, environmentally protective, and enforceable so that it is holding everyone to the same standards. An

Environmental Impact Analysis and cost-benefit analysis is currently underway. Issues associated with the standard include addressing the full range of organisms, life stage issues such as cysts, human health risks posed by indicator microbes, and potential risks to shellfish when the basis for microbes is a human health standard.

Ballast treatments are being explored, and this will include prototype installations, such as the Shipboard Technology Evaluation Program, development of ballast water management technology test protocols through the EPA ETV Program, and technology audits. Ballast water treatment systems will be evaluated based upon the performance against the standard and will not be technology specific. Evaluations will use a standardized process and scientifically-based approval tests.

The ETV Technology Panel supporting this effort is diverse and experienced, and benefits are derived from successive draft and comment revisions. Some of the ETV protocols are already in place at the facility being developed at the Key West Naval Research Laboratory, and protocols will continue to be improved through the Technology Panel drawing on multiple disciplines such as ocean engineers, mechanical engineers, physical oceanographers, microbiologists, naval architects, marine engineers, instrumentation engineers, marine biologists, and independent consultants.

Some technical innovations being developed to support testing activities include organism injection, sample extraction, and validation with vendor technology. These protocols and innovations will also have an international impact in the areas of approval guidelines and parallel test capabilities.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) arsenic treatment technology limitations for certain types of waters and how some technologies do not work well when high iron concentrations are present; (2) how the bench-level arsenic treatment tests are useful in controlled situations and how the ETV work is based on real water and real operating situations to enable the engineers to make a determination of how good the results are; (3) how engines today are much cleaner in their operation from those 20 years ago; (4) how current school buses are fairly clean from an emissions perspective; and (5) the existence of a fair number of school buses produced in the 1970s that do not have the types of engine efficiencies and emissions controls that exist today.

Public-Private Partnerships to Understand, Assess, and Adapt to Climate Change

Following opening remarks by Joel Scheraga, with ORD, six speakers addressed activities in support of the U.S. Global Change Research Program, applications of an energy sector model to assess future air pollutant reductions achievable from potential transportation measures, research efforts to understand stressors of coral reefs and visualization tools to assist in measuring coral population changes, a GIS-based predictive model for wildfires and resulting value impacts to support planning and decisionmaking, impacts of climate change on water systems and combined sewer overflows, and efforts to understand how decisionmakers obtain and use scientific information to improve information dissemination and utility. An audience question and answer period followed the presentations.

The Global Change Air Quality Assessment: A Collaborative, Cross-Laboratory Effort to Evaluate Future Air Quality

Dan Loughlin, with NRMRL, discussed a cross-laboratory effort to assess global air quality changes in support of the U.S. Global Change Research Program, which is drawing on the resources of 13 federal

agencies, including EPA, DOE, NASA, the Department of Commerce, and the Department of Interior, among others. EPA's role is to look at the impacts of global change on future ambient air quality (i.e., in the year 2050) considering population growth, economic growth, land use change, resource constraints, technology and fuel use changes, climate changes (e.g., temperature, precipitation, solar isolation), and current and expected national, regional, and state actions. Under overall coordination by NCEA, NERL is providing meteorology, emissions, and air quality modeling support; NRMRL is developing technology change and emissions scenarios; and NCER is providing links to the academic research community through the Science to Achieve Results (STAR) program.

The process of modeling to the year 2050 is a relatively new task, so EPA is looking at existing tools and methodologies to see what development is needed. Efforts are anticipated to expand the state of the art and to expand the tools for integrated modeling of meteorology, emissions, land use, and air quality. Sensitivity and uncertainty analyses are also being conducted. Activities include the development of tools to help EPA, regional, state, and local decisionmakers assess options to reduce future ambient pollutant concentrations and to identify robust approaches for adaptation to global change.

This involves a multi-model process that includes future scenarios that feed different steps in the model. Components include economic growth leading to changes over time, evolution of technologies such as future emissions characterization leading to ambient air quality, and regional meteorology that addresses both emissions characterization and air quality through photochemistry and transport. Other aspects include technology change (e.g., how emissions growth changes with improved energy efficiency) and land use change (e.g., how future emission sources are going to be distributed). Evaluations are still underway to select economic growth and land use change models.

The primary output of these efforts is an air quality assessment linked to the year 2050; an interim report is due in 2007 and the final report is due in 2010. Primary outputs for the EPA efforts include vehicle fleet technology penetration scenarios (with the Office of Transportation and Air Quality), integrated modeling tools (with OAQPS), and a repository of information on future technologies (with the Office of Atmospheric Programs). Outputs for the EPA regions, states, and local agencies include tools for assessing options to address long-term air quality concerns that are being developed through work with the Northeast States for Coordinated Air Use Management (NESCAUM). Discussions are also underway with DOE and others in the energy modeling community.

Gary Kleiman, with NESCAUM, discussed the development and application of the MARKAL model for use in New England (NE-MARKAL) to assess potential future improvements in air quality resulting from transportation measures under consideration. This tool is providing New England states with a tremendous opportunity to undertake multi-pollutant air quality planning. This is useful because there are a number of State Implementation Plans due in 2007 and 2008 for NAAQS compliance, many New England states are in the California Low-Emission Vehicle (LEV) program and they must understand the implications and possible credits resulting from a number of transportation measures, and these states are looking on their own at a number of state/regional transportation actions that may be undertaken for other air quality purposes. In undertaking these analyses, it is necessary to look across pollutants and across sectors to understand the interactions between the transportation sector and its programs and corresponding changes or effects on fuel prices or other economic impacts on the industrial or residential sector, as well as understanding changes of the technology infrastructure.

A particular strength of the NE-MARKAL model is the ability to look at the whole energy infrastructure from resource extraction through the demand for energy. The model is very comprehensive and enables the analysis of the interactions between different fuel chains and understanding of the impacts when a new transportation program is introduced; for example, the effects of demand/supply of fuel in other economic sectors.

The NE-MARKAL model optimizes any particular technological scenario in terms of least cost. An example scenario involves NOx emissions. The New England states have done good job of controlling power plant emissions. However, with the need to prepare State Implementation Plans, these states need to understand how to achieve more reductions in transportation sector. Graphs of historical and projected transportation demand by type of transportation show increases in demand over the next 30 years for every type of transportation (based on transportation types available in 2005). Using the NE-MARKAL model to use such a fixed technology characterization to assess future NOx emissions, an increase in NOx emissions is expected. However, this outcome is not realistic because there are more efficient technologies known to be in development and should come available in the future. If the NE-MARKAL model is allowed to consider a more realistic situation, such as adoption of the California LEV program, then a 10 to 20 percent reduction in NOx emissions is seen over the next 30 years.

With this modeling tool, it is possible to look also at theoretical maximums. For example, if everyone was required to have a hybrid vehicle, a 70 percent reduction in NOx emissions may be achieved. That is a significant level of reduction. However, the real question is how to time these efforts and to identify what measures will help get closer to this theoretical maximum without additional regulatory measures.

As an example, can automobile efficiency be improved through a state- or regional-level efficiency improvement programs such as feebates and what are the NOx co-benefits (e.g., what kind of credit could be obtained for ambient ozone concentrations)? Feebate is the redistribution of costs from less efficient to more efficient vehicles; this influences consumer behavior and helps to induce technological change. The NE-MARKAL model can help to understand the latter. To illustrate this, a chart was presented of various vehicles, their miles per gallon, and the type of fee the consumer might pay or the type of rebate that a consumer might receive based on vehicle type. The NE-MARKAL model was then used to look at changes in emissions from the use of a feebate program on a long-term basis. Because the NE-MARKAL model results are in a multidimensional data cube, they can be probed to analyze a program in many different ways, such as NOx implications, cost implications, etc. An example is the finding that if the size of the feebate is doubled, there are no significant improvements over the initial feebate analysis; this indicates that the initial analysis may be an appropriate starting point. In using this to prepare a State Implementation Plan, it appears that the transportation measures being considered may generate long-term impacts, but will not help in the short term.

Future applications of the NE-MARKAL tool may include analysis of programs that the New England states are currently considering, such as smart growth tax credits to reduce vehicle miles traveled, regional feebate programs, use of low sulfur heating oil, and combined heat and power incentive programs. This tool has potential for analyzing multiple pollutants, which will help in the analysis of these programs in a comprehensive and meaningful manner.

In conclusion, the NE-MARKAL model allows analysis and quantification of expected economic and environmental benefits of regional programs, and can help to provide a description of the technology path to get there.

Coral Condition and Global Climate Change: Assessment Tools for Resource Management

William Fisher, with NHEERL, discussed collaborative efforts to build capacity to assess and respond to global change impacts on fresh water and coastal ecosystems. A particular area of focus involves coral reef ecosystems, which have high value from tourism, fishing, shoreline protection, and natural products, and have valuable functions that result from the massive amounts of coral and the complexity of the coral

structure. Like a tropical rainforest, coral reefs lead to high biodiversity, species abundance, trophic complexity, and productivity.

Coral live in stable, oligotrophic conditions, and tend to be located in shallow waters to get the necessary light penetration. Coral reefs also thrive in temperatures near their thermal maximum, yet are sensitive to changes in water, temperature, and light. Thus, atmospheric change and land use change can directly and indirectly affect coral reefs.

Coral involves a symbiotic relationship between an animal (i.e., the thin layering over the calcified skeleton) and a plant (i.e., algae) that lives inside the coral. Photosynthesis by the algae provides energy for growth and reproduction of the coral. When algae leave or are expelled from the coral, the animal tissue has no pigment and has a bleached appearance. Bleaching caused by algal overgrowth, disease, or mortality (from temperature, solar radiation, or water quality) leads to colony erosion and reef disintegration. However, coral colonies can recover because the photosynthetic algae can recolonize if the stress is not too great. One of the primary causes of coral bleaching is water temperature and strong bleaching events appear to coincide with El Nino events.

An objective of this integrated research approach is to develop tools to evaluate coral value, health, sustainability, and risks. Field activities include characterization of coral condition and stressors. Laboratory activities include the establishment of dose-response relationships of corals and symbiotic algae with stressors. EPA is also attempting to overlay these data using geospatial analysis of coral condition to see where condition and stressors overlap and which stressors are most important.

Dose-response relationships of coral are being examined in the laboratory by varying temperature, ultraviolet-A, ultraviolet-B, sediments, nutrients, and contaminants. Bag culture technology is used to culture *Symbiodinium*, the algal symbiote, which is then exposed to various stressors. This approach serves as a screening mechanism to indicate what is important to the algae. Experiments that varied ultraviolet radiation and temperature together confirmed that ultraviolet radiation exacerbates the effects of warmer temperatures leading to significantly increased algae death rates.

EPA is collaborating with NOAA in conducting field measurements of stressor impacts such as temperature, solar radiation, disease, and water quality. The major study areas are the Florida Keys National Marine Sanctuary and the Dry Tortugas National Park. These studies are finding variability in nature for some of the exposures/stressors. One example is ultraviolet light penetration by depth below water surface in which a 10-fold decline was found at 1 to 2 meters in one area and at 10 meters in another.

Field activities are also designed to work with resource managers in American Samoa, Guam, Puerto Rico, and the Virgin Islands. In these areas, there is little technology in use; instead, divers knowledgeable about corals conduct assessments of coral populations for abundance and composition. This is particularly important for staghorn and elkhorn coral, which are being proposed for listing as threatened species under the Endangered Species Act, because these corals have suffered large declines.

Measuring bleaching, disease, abundance, and composition of corals is not helpful enough to resource managers. So, efforts are underway to develop a simple, rapid underwater survey of species, estimates of size, and estimates of living tissues for each colony to develop useful indicators of value, health, and sustainability for different coral species, different reefs, and different regions. This requires surface area estimates of coral colonies in the field, which is difficult to do because corals are highly convoluted organisms. This approach involves the estimation of the linear dimension surface area by having diverse photographs taken of coral colonies from multiple angles and applying a commercially-available software program for 3-dimensional modeling; this can account for both living and dead surface area.

A new application of this technology has begun to map colonies over several years in order to estimate growth/erosion rates in the field in different areas. This is very important for determining sustainability of a system.

Decision Support for Managing Wildland Fire Risk

Barbara Morehouse, with the Institute for the Study of Planet Earth at the University of Arizona, discussed efforts to build a decision support model to assist with strategic planning for wildland fire management through grants from NOAA and the EPA STAR program. There are 211 million acres in deteriorating condition and at high fire risk, primarily in the western U.S. In the southwestern U.S., there is a particularly strong El Nino/La Nina signal and some relationship with the Pacific Decadal Oscillation. Under conditions of climate change and using the types of models run to date, current thinking is that the El Nino/Southern Oscillation process will be intensified under conditions of climate change resulting in more extreme/severe events. The El Nino and La Nina forecasts are now fairly dependable and these can be linked closely with regional fire regimes and large fire years such as those experienced in the winters of 1998-1999 and 1999-2000.

Fire climate workshops were held to get fire managers and climatologists together to discuss these relationships. One of the recommendations was to develop tools, such as models, that integrate climate into planning and decisionmaking. The web-based GIS model developed in response is designed for strategic planning (seasonal or longer), is not intended for tactical planning during an event, and is built for use by experts and nonexperts, including community members and fire managers. The resolution is 1 square kilometer, which is the finest scale possible for climate information, and the focus is on fires that are greater than 250 acres because these fires are statistically most likely to grow to project size fires that require external resources to fight.

Fire managers and fire experts were drawn upon to be sure the model was correct. A series of evaluation sessions were then held with community members, fire experts, and fire managers to discuss this initiative, walk through the model, discuss results, and obtain feedback. The study area used for this effort was in the mountain range level, involving three areas in Arizona—two in the Coronado fire management areas and one in the Santa Fe National Forest.

The GIS-based model, Fire and Climate Society Version 1 (FCS-1), is the first to combine climatic information with human values. FCS-1 includes two submodels—one that looks at the basis of fire probability and one that looks at "values at risk," which are an array of human values. The layers in the fire probability submodel include a fuel moisture stress index (which links a user-selected climate scenario with fuel moisture levels), a fire return interval departure area (which is fire history data from fire atlases and fire maps that the system assesses at the pixel level to determine departures from what is expected under normal conditions), and a fire ignition probability component that addresses the statistical probability that an ignition will grow into a fire. Researchers found that there were 20 years of data for almost all items of interest except lightning for which there was only 10 years of data; this was not a difficulty because lightning data are predictable and lightning tends to strike over and over in the same areas. The submodel includes human factors for fire ignition (because humans cause over half of wildfires) and looks at relationships between human activities and where ignitions occur through regression analysis of proximity to roads, campgrounds, picnic areas, and urban areas; note that human-caused fires tend to occur in non-forested vegetation sites.

To develop the submodel on "values at risk," graduate students interviewed fire managers, business owners, and community members in various regions to identify where they visited regularly, how they get there, what areas they think are most likely to burn, and what they would hate to see destroyed in a fire.

These data were mapped and digitized to support automation. Another layer is recreation value, which is the biggest use in all of the study areas; this is based on surveys regularly conducted by the USDA, and specific activities were weighted by the number of visitors conducting them and then aggregating the information on a 1 kilometer basis. There are additional layers for property value and species habitat richness.

The model is driven by user-selected climate scenarios. Users can apply a predetermined expert weighting scheme to weight specific scenarios or may apply weightings they have developed. The model output is a fire risk map for each submodel and for the integrated model, and these maps can be used for decisionmaking.

The model, animated maps, fire history maps, wildfire-climate regression analysis, an interactive policy tool, and additional information can be found at: http://walter.arizona.edu.

Protecting Our Water as Climate Changes

John Furlow, with NCEA, discussed possible impacts of climate change on water quality. Typically, the climate change emphasis is on precipitation and how it changes the source water and receiving water, but there are other considerations such as temperature and sea level rise. As the climate changes, will communities be able to continue to provide clean, safe water? Several projects are underway to address this question and include coastal water systems at risk from sea level rise, impacts on combined sewer system overflows, correlation of SDWA violations and weather events, and how wastewater treatment plants operations can be affected by changes in receiving water composition.

Are drinking water intakes are vulnerable to sea level rise and, if so, what is the scale of this problem? Maps show many intakes along U.S. coastal areas, and this raises the question as to the number of communities that obtain their water from those areas. Rather than attempt to model every river for salt water intrusion, a series of assumptions regarding vulnerability were developed and used to screen the water systems. Water systems were considered less vulnerable to sea level rise if the intake was above the fall line, was more than 3.5 meters above sea level, or was protected by a dam or waterfall. Initially, it was assumed that the massive flow of fresh water in the Mississippi River would be protective, but this was later found to be inaccurate. This screening process identified 39 systems at low elevation or otherwise unprotected from sea level rise.

The next step was to estimate vulnerabilities and the primary premise was that water intakes closest to brackish water were the most vulnerable to impacts from sea level rise. Wetland maps of estuarine areas produced by the U.S. Fish and Wildlife Service were used to estimate water intake distance from brackish water; the intakes were mapped using color coding for high, medium, and low vulnerability.

This analysis indicated that six systems had high vulnerability and five systems had medium vulnerability. By contacting these facilities, researchers determined that the vulnerability assignments and study assumptions were generally correct; in one case, the water system was destroyed in a hurricane, but had repeatedly experienced operational problems in the past and could only be operated at low tide. All of the other facilities reported having operation and backup plans because of their concerns in this area. The study results indicated that not many people would be affected by sea level rise with regards to water supply.

For combined sewer systems, rainwater from streets and sewage go through the same pipes and small weirs in the system divert the flow to wastewater treatment plants. If the volume is too large, the combined wastewater can overflow the weir (i.e., combined sewer overflow) and go directly into waterways or the ocean without treatment. As a result, about 850 billion gallons of untreated sewage and

storm water are released yearly—primarily in the Great Lakes and the Pacific Northwest. These overflows are in conflict with CWA requirements to have no more than four overflows each year and to eliminate or capture at least 85 percent of such discharges. In addition, the U.S. has invested heavily in this infrastructure and maps of precipitation increases/decreases in last 100 years show that precipitation increases are primarily in areas where combined sewer systems are located.

If the control plans for combined sewer systems are based on historical weather data, the question arises as to whether climate change might diminish the effectiveness of investments in such systems. So, a study was undertaken in New England to look at whether or not the control plans would be effective 20, 30, or even 50 years from now given the patterns associated with climate change. A key question involved the size of the benchmark (e.g., threshold) storm that would cause combined sewer overflows and whether the magnitude of such a storm will become more or less frequent.

There are 135 combined sewer systems in New England. Using down-scaled information from Canadian and Hadley climate models, the number of communities affected and the percent change in the number of storms above/below the threshold storm were mapped. According to the Canadian model, there will be a decline or no change in the frequency of the threshold storm; however, the Hadley model indicated that there might be a slight increase in such storm events. The next steps are to work with system managers in the New England area to learn how their plans are developed, whether they considered climate change, and how these results might be used in their planning. Non-point sources of pollution and ways to deal with pollution problems that are not necessarily infrastructure intensive or expensive will also be examined. For example, the City of Portland has a program to disconnect household gutters from sewer systems to reduce flow.

Use of Science in Gulf of Mexico Decisionmaking Involving Climate Change

Arnold Vedlitz, with the Institute of Science Technology and Public Policy at Texas A&M University, discussed partial findings from research underway to understand what decisionmakers and the public need to understand about the uncertainties surrounding complex scientific information, including what to do with it, how to assess it, how to package it, and how to incorporate it into policymaking. Developing such an understanding will facilitate movement of science to stakeholders and decisionmakers.

The decision model underlying this study involves knowledge producers (such as scientists in academia, industry, national laboratories, etc.) who generate information on climate change and mitigation strategies, and the movement of this information (either directly or indirectly) to knowledge consumers (such as decisionmakers, scientific committees, etc.). Indirect knowledge transfer occurs through intermediaries such as the media, federal committees, National Academies, various government agency personnel, etc. The overall goal is to provide EPA with information on how climate change issues become identified as problems, what is relevant, what are valued/trusted information sources, appropriate information types and formats, and how to best frame, package, and deliver objective science and technological information for the most effective consumption and use by policymakers and the public.

There are three sample locations—one in Texas, one in Louisiana, and one in Florida. In each location, 200 stakeholders and policymakers are being interviewed in two waves. The first 100 in each location were selected through random sampling and include key organizations that might be involved in water/environmental management such as businesses, fishermen, environmental groups, and elected or appointed officials. The second wave will involve interviews of another 100 at each location.

The interviews are unstructured and last about 1.5 hours. Interviewees are asked about their major problems, how they dealt with them, and how they get and assess information. The interviews are transcribed, processed, and coded; the average transcript is 16 to 17 pages. The first round of interviews

is being transcribed, the second wave of interviews is underway, and in about 7 months the interviews will be completely coded and ready for analysis.

Processing and coding involves five groups of 50 variables each. While content analysis can be done with software packages, humans need to be involved to get more detailed, qualitative data. Content analysis of the interview narratives is conducted with human coders using a software package called "In Vivo." The software divides the computer screen into two halves—on one side is the narrative from the interview and on the other side are predetermined categories of importance. The human coders look at the narrative and move the actual words to the coding category. There are multiple coders, so it is necessary to address coding consistency.

Based on preliminary data from 112 interviews, the environment was by far the most important problem identified by the interviewees; this means that EPA is doing a good job of getting out the message and that the information produced by EPA is valuable and useful. In the area of information type/subject, interviewees believe that environmental and technological fixes will be needed more than government regulation, economic, or socio-demographic solutions. In the area of information medium, there is a clear preference to receive information in printed form or in a professional setting such as a conference, which was a surprise to researchers; television and the Internet were identified as the least preferred media. In addition, the kinds of information that EPA is producing is of great interest to stakeholders and decisionmakers who are trying to address specific problems.

The analysis area of information source addresses who the interviewees trust. Interestingly, the government (but not EPA specifically) was considered the most highly trusted information source; 80 percent of the interviewees identified the government in general and 20 percent identified EPA specifically as a trusted information source. This finding, while based on a portion of the interviews, is extremely important and points to a need for EPA to make information more user-friendly and to get the information out to the stakeholders and decisionmakers. Other agencies, such as NOAA, U.S. Army Corps of Engineers (USACE), and the National Weather Service, appear to be doing a better job in the latter area.

In the area of information barriers, there are things that decisionmakers want to know, but believe that either there are no data available or there is not enough data. There also is great uncertainty in many areas, such as which model is right, which scientist is right, which scientist is wrong, etc. In addition, many felt that the information provided was incomprehensible. Thus, there is a need to develop tools to help move scientific data into a form that policymakers use.

Another research activity involves a news analysis of articles in the *Houston Chronicle* (the largest newspaper in Texas and the 10th largest circulation in the U.S.) for a 12-year period from 1992 through 2003. While decisionmakers say that newspapers are not an important source of information to them, much of the public does look at what is being said on television and in the newspapers. The analysis found that the number of articles on climate charge is increasing over time; two peaks occurred and coincide with the Kyoto accord and U.S. withdrawal from that. The media message is that global climate change is harmful and that harmful image is increasing over time, with energy and science as big components. This illustrates what is the topic of conversation in the media and with the public. In this area, the government elements most highlighted are the President and federal agencies, followed by Congress then state government.

In the area of solutions, most of those interviewed selected mitigation. Decisionmakers were split on whether mitigation should involve governmental or nongovernmental action; most desired ecological then technological solutions. Another finding is that there is a lot of scientific information in the news

organizations and the primary information sources are considered independent (e.g., the government and universities).

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) the importance of stakeholder outreach in developing FCS-1 including meetings in their own towns and researchers being open to changing the structure of the meeting to accommodate things that are important to the stakeholders, (2) the need for iterative outreach efforts to involve technical resources and stakeholders throughout the model development effort, (3) the consideration of population growth (e.g., number of cars, etc.) in the NE-MARKAL modeling that demonstrated the ability to achieve more NOx reductions with increased demand over time through implementation of NOx reduction technologies, and (4) the techniques being used to ensure that what interviewees report as their behavior is actually what they do, including analysis of written materials produced by participating groups and stakeholders, attending and observing meetings of these groups, and holding focus groups.

Section VI: Regional Track

Tuesday and Wednesday, May 17-18, 2005

The purpose of this breakout session on the second and third days of the meeting was to focus on regional initiatives and research being conducted regarding marine ecosystem health, mercury transport and bioaccumulation in the environment, challenges presented by both old and new pathogens, salmon habitat restoration, the use of landscape tools to assess water quality vulnerability, and air toxics issues. Each session included opportunities for the speakers to respond to audience questions that provided additional information and insight on a variety of scientific, environmental, and program topics.

Jonathan Garber, with NHEERL, led a session addressing the assessment and management of the marine environment. Presentations included an overview of collaborative efforts for monitoring and managing coastal conditions, the development of rapid bacteria monitors, the effects of urban sprawl, the development of an invasion pathway analysis and ballast water screening tool, transport and secondary spread of invasive species, Asian oyster introduction in the Chesapeake Bay, biological methods research collaborations, and integrated risk analysis.

Patti Lynne Tyler, with EPA Region 8, led a session addressing the transport and bioaccumulation of mercury in the environment. Presentations included a multi-media conceptual model for examining environmental mercury, risks posed to the Cheyenne River Sioux Tribe by mercury in fish, and an overview of the research used in to develop the Clean Air Mercury Rule.

David Macarus, with EPA Region 5, led a session addressing the challenges presented by new and old pathogens. Presentations included an overview of the overall pathogen challenge, chronic wasting disease, the Microbial Source Tracking Guide, quicker water quality measurement devices, and collaborative monitoring efforts in New York City.

Derek Poon, with EPA Region 10, led a session on restoration actions and salmon productivity in the Pacific Northwest. Presentations included discussions of the Intensively Monitored Watersheds Program, including watershed monitoring, linkages between watershed conditions and salmon population declines, and salmon response to habitat actions.

Brenda Groskinsky, with EPA Region 7, led a session addressing the use of landscape tools to assess water quality vulnerability. Presentations included discussions of the need for vulnerability assessment tools in the White River Basin and the development of water quality indicators to use in such tools.

Mike Callahan, with EPA Region 5, led a session addressing collaborative efforts at the local level to clean up air toxics. Presentations included overviews of the challenges involved in dealing with air toxics, examples of dioxin and PM air emissions characterization studies, emission characterization using remote sensing technology, and linking air toxics to human health effects.

How Healthy Are Our Marine Environments?

Following opening remarks by Jonathan Garber, with NHEERL, eight speakers provided an overview of collaborative efforts for monitoring and managing coastal conditions, the development of rapid bacteria monitors, the effects of urban sprawl, the development of an invasion pathway analysis and ballast water screening tool, transport and secondary spread of invasive species, Asian oyster introduction in the Chesapeake Bay, biological methods research collaborations, and integrated risk analysis. An audience question and answer period followed the presentations.

The National Coastal Assessment: Working in Partnerships with Regions, States, and Tribes to Monitor and Manage Conditions in the Coastal Ocean

Hal Walker, with NHEERL and Northeast Coordinator for the National Coastal Assessment program, discussed the collaboration between the National Coastal Assessment, states, regions, tribes, and academia to develop tools for coastal ecosystem assessment and evaluation, and the ways in which existing National Coastal Assessment research can be used to enhance other regional research projects. The National Coastal Assessment collaborations focus on the following:

- Assess the ecological condition of estuarine resources using unbiased data of known quality
- Determine reference conditions for more detailed studies on ecological responses and stressors
- Build infrastructure in states and EPA Regions.

The purpose of this collaboration is to gain an understanding of coastal ecosystems and to improve the delivery of information to participants. National Coastal Assessment partners from across the country include federal and state agencies, as well as universities. The intention of the National Coastal Assessment is to hand off parts of this project to coastal states through the Office of Water.

The National Coastal Assessment baseline studies can be used in conjunction with more detailed regional studies, such as the Regional Environmental Monitoring and Assessment Program (REMAP), Regional Methods Initiative, and Regional Applied Research Effort (RARE) projects. Examples of projects being conducted in the Northeast include: REMAP probability-based studies and targeted monitoring at higher spatial and temporal resolution; Regional Methods Initiative work to identify and evaluate toxicity and the effects of black carbon on the bioavailability of polycyclic aromatic hydrocarbons (PAHs); and RARE projects on comparing different epifaunal indexes and conducting near real-time, *in-situ* measurements of fecal contamination. There also are other real-time management studies being conducted that could benefit from the use of National Coastal Assessment data, and combining the data provides a better image of the coastal ecosystems.

The National Coastal Assessment program is working on electronic reporting concepts, such as GIS visualization tools and statistical analysis tools. These tools, in Excel, ArcExplorer, and ArcMap formats, make the data more accessible and easier for the states to use as they begin to manage the data. These tools will allow the users to visualize data structures and re-compute summary statistics; for example, users will be able to visualize spatial variations and gradients in coastal conditions. State and local problem solving will be facilitated by features in the Excel tool that allow the user to change thresholds (i.e., good, fair, or poor). Electronic reporting allows for the comparison of data and affords the user the ability to dig into the data to determine the root of the problem. The National Coastal Assessment program is planning to make these tools available on a web site.

The National Coastal Assessment program is in the process of transitioning the monitoring and assessments to state and tribal environmental programs. The data and the tools to use the data are being transferred in electronic form. The National Coastal Assessment program will add some high-resolution data to the assessments and data sets being provided to the actual users. This will result in better

decisionmaking at the local level. Forming partnerships early in this process facilitates the transfer because data can be packaged to suit the needed format of the end user (i.e., states and tribes).

Developing Rapid Bacteria Monitoring to Protect Public Health

David Turin, with EPA Region 1, discussed the current methods used for bacteria detection at New England beaches, the need to develop real-time bacteria detection methods, and collaborative research funded by the RARE Program to address this need. As a result of The Federal Beach Act (2000), there has been an increase in the number of beaches being monitored for bacteria and in the frequency of monitoring with some beaches monitored daily. The increased monitoring has resulted in many closure days at New England beaches. Data on the number of closure days at New England beaches indicates a correlation between wet years and an increase in the number of closure days. The data also indicates that the condition of the beaches is improving (i.e., there is a decrease in the number of closure days). This is partly a result of the more frequent monitoring, which has helped some beaches identify problems (e.g., storm water runoff and other connections) that previously were not known.

Current methods being used to detect bacteria at New England beaches include multiple tube fermentation, membrane filtration, and fine substrate. Multiple tube fermentation provides an indication of the density of bacteria growth, rather than an actual bacteria count, and therefore, is probably not the best method to use. Although, membrane filtration does provide a direct count of bacteria colonies, a newer method, fine substrate, is more specific. The advantage of the fine substrate method is that it provides fewer false positives and takes the same amount of time to perform as membrane filtration. The key problem with the current bacterial detection methods is that they all take 24 to 48 hours to produce results. This delay means that beaches are often open on days when they should be closed. Thus, there is a great need for improved bacteria monitoring that would provide results more quickly to decisionmakers.

To address this need, the RARE program has funded collaborative research to develop a rapid bacteria detection method. Collaborators on this project include NHEERL, NERL, the University of Rhode Island, SubChem Systems, Inc., EPA Region 1 Office of Ecosystem Protection, and the Rhode Island Department of Health. The research objective is to determine the feasibility of combining existing monitoring technologies with an optical detection system.

The first prototype, a bench-top model built into a suitcase, has provided very encouraging results. Bacteria could be detected in 3 to 7 hours, depending on the density of the bacteria. Although the prototype proved to be considerably more sensitive than had been anticipated, it is still a work in progress. The next stages of development include improved temperature control for incubation, and the development of biofouling protection. The goal is to develop an autonomous system that can function and report data to an operator all on its own. Ideally, this will be a hand-held model.

Can We Control Urban Sprawl in the Chesapeake Bay Watershed?

Carin Bisland, with the EPA Region 3 Chesapeake Bay Program, Peter Clagget, with the USGS, and Laura Jackson, with NHEERL, discussed some of the activities of the Chesapeake Bay Program, its goals, and the need for new tools to attain these goals. The Chesapeake Bay Program is run by a series of agreements between the States of Maryland, Virginia, Pennsylvania, and West Virginia; the District of Columbia; and EPA. The goal is to reduce the rate of harmful sprawl within the Chesapeake Bay watershed by 30 percent by the year 2012. Activities of the Chesapeake Bay Program to attain this goal include:

- Outlining principles of good development

- Sponsoring a tax policy study
- Sponsoring workshops on environmentally-sensitive development practices, sound land use and watershed planning, and land conservation planning and funding
- Assisting in the development of watershed management plans
- Modeling urban growth
- Monitoring change in impervious surfaces
- Tracking land protection efforts.

Coastal areas are highly impacted by what goes on in the watershed. Population increases (i.e., urban sprawl) result in increases in impervious surfaces. As the amount of impervious cover increases, increases are seen in aquatic system degradation and the presence of toxic trace elements in the streams. The focus of controlling urban sprawl is on the local level, and local governments need help to make better decisions about development practices and procedures. One of the challenges is measuring the effects of urban sprawl.

An urban sprawl conceptual model shows the correlation between per capita growth and the increase in impervious surfaces. The model uses impervious surfaces as a measurement of high impact areas. The model considers attraction, footprint, and local factors that contribute to the amount of impervious surface. Because urban sprawl is not likely to be controlled, it is important to determine which areas will suffer the greatest impact and to safeguard those areas from the effects of development. By combining maps, the model can pinpoint areas of high ecological value.

A measurable difference could be made on the landscape by targeting resources on the imminent threat areas. Tools are needed to model growth and target applications in such areas. Through a RARE grant, the New Jersey Growth Model was developed. This model is a decision support system that spatially allocates projections of future housing and employment, and enables the exploration of alternative future developments. The plan is to customize the New Jersey Growth Model to the Chesapeake Bay watershed using local data to prepare historic development estimates. These historic estimates, coupled with population data and employment forecasts, will aid in the projection of future development. Historic growth patterns and trends can also be used to develop smart growth scenarios. Baseline scenarios will be put into the model and the output used to evaluate water quality changes based on different future development scenarios. The model also can be used to project impacts of wastewater treatment scenarios. All of these approaches integrate water use planning and land use planning.

Invasion Pathway Analysis and Ballast Water Screening Tool Development: A Regional Perspective

Joan Cabreza, with EPA Region 10, discussed the rationale and background information necessitating the development of a pathway analysis and screening tool and potential uses for the tool in EPA Region 10. The driver of this study, Executive Order 13112 on Invasive Species, mandates that "*Each Federal Agency shall…use relevant programs to…prevent introduction …detect and respond rapidly to control populations…monitor…conduct research & develop technologies to prevent introduction and provide control…promote public education…and not authorize, fund, or carry out actions that…promote the introduction or spread of invasive species…*" This ballast water study, funded by a RARE grant, builds upon the methodology development work done in EPA Regions 5 and 9. Partners in this cooperative effort include the University of Washington, Pennsylvania State University, the University of California-

Davis, the Washington Department of Fish and Wildlife, the Washington Department of Natural Resources, the USGS, industry, and ORD researchers.

The San Francisco Bay is the focus of this study because it is a huge port with more pollution than anywhere else in the U.S. and it also is the source of most of the exotic species found in the States of Washington and Oregon. More than 230 exotic species are established and flourishing in the San Francisco Bay. The study assumes that exotic species populations found in other West Coast areas that are genetically identical to those in the San Francisco Bay must have originated in the San Francisco Bay. A genetic database of organisms is needed to support broad technology application.

Ballast water is known to be the principle pathway for introduction of exotic aquatic species. Ballast water contains approximately 12,637 organisms per cubic meter and 21 billion gallons of ballast water are discharged to U.S. waters each year. Exotic species introductions are increasing as a result of ballast water uptake in high species density areas; increases in global trade, travel distances, ship sizes, ballast volumes, and speed; and each infected area becomes a new source area.

Traditional morphological taxonomy is limited for many reasons and makes traditional species identification a challenge. Therefore, this study uses DNA taxonomy to identify ballast water species. The advantages of DNA taxonomy include:

- Difficulty of identification depends upon the application
- Ability to classify eggs, larvae, and adult specimens
- Broad taxonomic knowledge is not required
- Ability to identify organisms to the subspecies level
- Provides an objective standard that allows cross-study comparisons.

Work conducted in EPA Region 5 focused on the sequencing of about 100 species considered to be established exotic species and likely invaders, including Zebra and quagga mussels, Eurasian ruffle, round and tubenose gobby, fish-hook and spiny water fleas, amphipods, and copepods. EPA Region 9 began to build upon this work and is now working with EPA Region 10 to examine about a dozen species found both in San Francisco and EPA Region 10 estuaries. These species include European green and Chinese mitten crabs, *Spartina* spp, polychaetes, and bryozoans. The goal is to examine additional species as funding becomes available.

Once sufficient species are sequenced, there will be many potential applications to ballast water regulation development and enforcement. For example, although current state regulations require that ballast water exchange occur 50 miles off shore for ships entering from outside a U.S. Exclusive Economic Zone, so interstate coastal traffic is not subject to this requirement; proof of interstate species transfer may result in changes to state regulations for ballast water exchange. As another example, enforcement of ballast water exchange is currently difficult and is time-consuming to verify. Development of a ballast water screening tool would allow for rapid sampling and accurate verification, and such a tool could be used to determine if organisms in the ballast water samples are oceanic or coastal. Other applications for the genetic screening tool include its use in early detection and monitoring programs, coastal risk and vulnerability assessments, and source evaluations to trace invasion pathways.

Regional Transport and Secondary Spread of Invasive Species in Pacific Coast Estuaries

Mike Blum, with NERL, discussed studies that have been conducted to determine if invasive species are spreading via secondary introductions. This collaborative project, funded by EPA Regions 9 and 10 RARE grants, supports ballast treatment technology development, ballast management and policy

development, early detection and monitoring, and risk assessment, and is also examining broader issues spanning the States of California, Oregon, and Washington. Invasive species are severe anthropogenic stressors of aquatic systems and the spread of invasive species is leading to major global changes in biotic diversity and ecosystem functions. Ballast water is the principle vector for introduction to estuaries and 3,000 to 10,000 species may be transported worldwide on any given day.

The research objectives are to examine transport pathways across estuaries and to characterize transport of invasive species in coastal and intercontinental shipping. To address the question of whether invasive species spread via secondary introductions, the invasions by smooth cordgrass (*Spartina alteriflora*) and the European Green crab (*Carcinus maenas*) were evaluated. Preliminary results of chloroplast DNA analysis of genetic variation of smooth cordgrass populations found in the San Francisco Bay and two areas in Washington State (Grays Harbor and Willapa Bay) indicate that the populations in California and Washington are independently derived. However, the results also found that the populations in Grays Harbor are derived from the Willapa Bay populations. These results match up well with historic data.

The European green crab, which is now found throughout the world, was examined through microsatellite DNA analysis to gauge genetic diversity across invasive populations. The results of the analysis indicate that the Pacific Coast invasion is derived from an Atlantic Coast source, and that there is no loss of genetic variation between the populations found in the San Francisco Bay, Grays Harbor, WA, and at points along the Pacific coastline that are in between the two locations. The latter results were not expected and do not line up with historical data, which indicate that the green crab first invaded the San Francisco Bay then moved northward. Instead, the results suggest that the green crab spread locally via coastal currents. Long distance dispersal of the genetically identical populations could be attributed to a number of factors including unusually strong currents (e.g., El Nino events) and ballast water transport.

Work conducted on targeted screening of ballast water for invasive species assessed the transport of European green crab and Chinese mitten crab larvae in ballast water originating from invaded areas. Targeted screening involves sampling ballast water from coastal and intercontinental ship traffic, and development of diagnostic molecular screening tools, such as allele-specific polymerase chain reaction (PCR) and DNA sequence analysis. Research results indicate that diagnostic markers can be used to differentiate between species and to identify hybrids.

Preliminary research results suggest that invasive species introductions are a mixture of independent events and secondary spread and that secondary spread results from transport by currents and ballast water. The studies on targeted screening and molecular inventories of ballast water present evidence for ballast water transport of the European green crab from overseas sources, molecular approaches can be used to distinguish among species and among genetic lineages within species, and molecular approaches can determine the genetic diversity of founding cohorts (a measure of invasion potential).

Asian Oysters in the Chesapeake Bay

Daniel Kluza, a post-doctoral fellow with NCEA, discussed the proposed introduction of the Asian oyster into the Chesapeake Bay, the proposal evaluation, and associated uncertainties. The Eastern oyster (*Crassostrea virginica*) accounts for 40 percent of all U.S. oyster production. However, current production levels are at 1 percent of the 1884 production levels as a result of a steady decline in production since the 1920s. This decline in production can be attributed, in part, to two non-native parasites discovered from 1950 to 1960. In 1950, a disease called Dermo was discovered; although there did not appear to be any immediate repercussions, the disease started to have an effect in the 1980s. In 1960, MXS was discovered and was found to have an immediate and significant effect—oyster production decreased from 30 million pounds/year to 20 million pounds/year. Aside from disease, anthropogenic factors impacting oyster production are eutrophication, sedimentation, and harvest.

In 1995, the Asian oyster (C*rassostrea ariakensis*) was chosen as an alternative oyster to revive the Chesapeake Bay ecosystem. This oyster was thought to be a promising species for introduction into the Chesapeake Bay because it is less susceptible to MSX and Dermo than the Eastern oyster and has a faster growth rate. There are currently two major deployments of Asian oysters: a proposed introduction in Maryland and aquaculture trials in Virginia.

The action proposed in Maryland is to establish a naturalized, reproducing, and self-sustaining population of Asian oysters. Evaluation of the proposed action in an Environmental Impact Statement (anticipated to be completed in 2007) is lead by the USACE with assistance from NOAA, the U.S. Fish and Wildlife Service, and EPA. The ecological risk assessment will be conducted by the Maryland Department of Natural Resources and Versar, Inc., and will be based on the National Research Council and Scientific Technology Advisory Committee reports. Both reports explored the general prospectus of the potential trial oyster introduction. Key points of the risk assessment will include problem formulation and assessment endpoints, risk analysis, and risk characterization. Assessment endpoints include, but are not limited to, blue crab, submerged aquatic vegetation, phytoplankton, zooplankton, water quality, and pelagic fish.

Because the presence of the Asian oyster can have many effects, a conceptual model is used to understand what might happen if the Asian oyster were introduced into the Chesapeake Bay. At this time, there is very little known about the Asian oyster or what kind of impact it may have. NOAA has outlined the knowledge gaps that must be filled.

The Virginia Seafood Council conducted triploid Asian oyster aquaculture trials from in 2003 and 2004. Although the oysters were scheduled to be harvested in June 2004, the harvest date was extended until April 2005. The aquaculture trials involve the introduction of 800,000 oysters across 10 sites. Although the oysters are triploids, about one in every 4000 oysters is a diploid, and therefore can reproduce. There is also the chance for spawning to occur. To quantify the risks and to determine how to manage the risks of Asian oyster introduction, a demographic model is being developed. Challenges in developing and using this model are that several critical input questions are currently without answers, such as shell height, fecundity, sex ratio, fertilization efficiency, larval mortality, and larval transport.

The likelihood of the Asian oyster being introduced into the Chesapeake Bay remains an open question. There is still a lot of uncertainty as to whether there is enough science to support such an action.

Overview of Regional Methods Program: Highlights of Biological Methods Research Collaborations between EPA Regions and ORD Laboratories

Treda Smith, with the Office of Science and Technology, provided an overview of the Regional Methods Program and discussed collaborations with the Biological Advisory Committee. The Regional Methods Program began in 1989 to provide for technology transfer from ORD laboratories to EPA Regional offices and is administered by the Office of Science Policy in ORD.

The Regional Methods Program process was formalized in 1994 when the Biological Advisory Committee began to set priorities for regional biological research needs. The projects coordinated by the Biological Advisory Committee under the Regional Methods Program were proposed based on needs identified by the EPA Regions. The projects have a 3-year funding maximum and are assigned to general areas of method development including air, tissue, marine chemistry, and biology.

The Biological Advisory Committee is composed of Regional, ORD laboratory, and Program Office biologists and technical staff, and assesses biological test methods and protocols that measure, integrate,

and monitor aquatic and terrestrial ecosystem health. The Biological Advisory Committee holds an annual meeting, which has enhanced cross-agency collaborations for 35 years. The role of the Biological Advisory Committee in the Regional Methods Program is to develop and maintain partnerships between the EPA Regions and ORD laboratories in order to prioritize funding of regional projects.

Project proposals in the biological area are aimed at high-priority, regional, measurement-related problems seeking near-term solutions. The proposals address the most critical methods problems identified by regional scientists. The projects selected to receive funding are those that have the widest applicability and/or the greatest national impact. To date, over 20 biological research projects have been funded through the Regional Methods Program and include the following:

- Developing sampling methods for large rivers and headwater streams
- Testing an excess sedimentation index developed through EMAP
- Assessing stream stress as a result of dissolved oxygen level fluctuations
- Developing diagnostic indicators for nutrients
- Developing biological indicators for transition zones
- Developing toxicity evaluation procedures
- Assessing the role of black carbon to PAH bioavailability in marine species.

The Regional Methods Program has been very successful in aiding the Biological Advisory Committee to foster research collaborations.

Integrated Risk Analysis in Coastal Ecosystems: The Example of Mercury

John Johnston, with NERL, discussed risk in coastal environments, multimedia exposure modeling, future work in modeling in the Chesapeake Bay and other coastal areas, and a pilot project in the Escambia River Delta. There are competing objectives in coastal ecosystems. One objective is to minimize the impacts of anthropogenic stressors on the ecosystems, such as resource harvesting, contaminants, nutrients, climate change, and recreation. Another objective is to maximize the economic benefits obtained from ecosystems by increasing the density of aquaculture farming, maximizing sustainable yields from fisheries, and promoting tourism. The ultimate goal is to maximize benefits while taking into account the risks of invasive species. The challenge is the uncertainties, which must be quantified and made a part of the risk assessment process; otherwise, they can hinder the process.

Mercury was chosen as a research subject because coastal and marine fish consumption accounts for approximately 80 percent of the methylmercury intake in the U.S. population. Mercury has been shown to be of particular concern to sensitive subpopulations, such as infants and women of childbearing age. Research has indicated that elevated levels of mercury can result in reduced Intelligence Quotient and other detrimental health effects in children, such as impaired motor and cognitive skills. However, the health risks from mercury consumption may not be limited to those subpopulations because studies have shown that mercury may also pose a cardiovascular risk for adults.

A conceptual model for the mercury exposure pathway was presented. Mercury in emissions from power plants and other sources are deposited into water bodies via atmospheric transport and deposition. Mercury transforms into methylmercury in soils and water where it can bioaccumulate in fish. Human and wildlife consumption of the fish results in the ingestion of methylmercury. Integrated analysis of source-receptors, aquatic fate and transport, bioaccumulation, and human exposure is required to understand the overall exposure pathway.

Use of the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model for the Chesapeake Bay was discussed as an example of source-receptor modeling. The HYSPLIT model is a

plume model that is very effective in providing a geographical distribution of mercury emission deposition, and it also illustrates the number and sources of high mercury emissions in the area. Application of this model shows that coal-fired electrical generation plants are accountable for the majority of mercury deposition in the Chesapeake Bay area.

However, not all mercury that is deposited transforms to methylmercury. Factors affecting methylation include: (1) the bioavailability of mercury in an ecosystem, which is affected by sulfide, chemistry, and the amounts and types of solids in water and sediments, and (2) the microbial activity that produces methylmercury, which depends on temperature, suitability of the environment, sulfate, organic matter, and other biological processes that affect the chemistry. For example, sulfide can inhibit methylation, while sulfate (from acid rain) can increase the methylation potential. Also, methylation and de-methylation are a set of competing processes.

In general, estuarine environments, such as the Chesapeake Bay, have the potential for high methylation rates because of high sulfate and sulfate-reduction rates. In addition, organic matter in the sediments of coastal systems strongly influences the bioavailability of certain forms of mercury. Also, methylmercury bioaccumulation correlates with life span; fish with longer lives, such as sharks and swordfish, have a much higher mean methylmercury concentration than smaller fish with short life spans.

There are many uncertainties in dietary mercury exposure and dose modeling. Human activity modeling uncertainties include the amount of fish consumed, the fish source, and the species of the fish. Physiologically-based toxicokinetic modeling and biologically-based dose-response modeling uncertainties include age, gender, health status, and genetic susceptibilities of the person eating the fish.

A pilot study was conducted in the summer of 2004 at the Escambia River Delta in Florida as part of the Altered Habitats Program. The study involved fisheries population dynamics in collaboration with NOAA; predictive habitat modeling by NERL and NHEERL; mercury characterization, fate, and bioaccumulation by NERL; and advanced monitoring such as mapping subaqueous soils (with the USDA) and dynamic habitat/designated use attainment.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer session addressed a wide range of topics. These topics included: (1) correlating human health with exposures; (2) the use of predictive models in decisionmaking regarding beach closures; (3) the impacts of public education on the amount of pesticide pollution in the water; (4) promoting "smart" landscaping to abate pesticide pollution; (5) pre-treating ballast water before release; and (6) high levels of mercury found in shrimp.

The Transport and Bioaccumulation of Mercury in the Environment

Following opening remarks by Patti Lynne Tyler, with EPA Region 8, three speakers discussed a multi-media conceptual model for examining environmental mercury, risks posed to the Cheyenne River Sioux Tribe by mercury in fish, and an overview of research used to develop the Clean Air Mercury Rule. An audience question and answer period followed the presentations.

Multi-Media Research on Mercury in the Everglades, Collaborations and Results: A Fruitful Decade of Field Studies and Modeling in South Florida

John Ackermann, with EPA Region 4, provided an overview of the conceptual model EPA uses to examine environmental mercury and discussed several collaborative mercury studies conducted in Florida. Understanding the risk of mercury to humans via the food chain is a fairly new science, and

much of the information comes from the last 20 years. Historically, the understanding of mercury in the food chain has come from fish tissue studies that focused on input pathways; environmental transport and fate; methylation, biomagnification, and food webs; models; and linking across media. The cutting edge research is in atmospheric dynamics and dry deposition studies.

The key aspect of the conceptual model is the multi-media component with a focus on the human side in this presentation. The levels of mercury in the general environment have increased three to five times over what the levels used to be, and a primary area of concern involves air emission sources. Although most of the mercury in air is elemental in its gaseous form, mercury does react with particles (such as calcium chloride) to transform into Hg(II), and most of the mercury in rainfall is in the reactive form. Methylation and biomagnification are key events for mercury in the food chain. The only way to eliminate mercury in the environment is through deep burial.

In the 1980s, Florida began to find mercury in fish. The large mouth bass and other large game fish contained dangerous levels of mercury, and a primary area of concern was the Everglades. Up until 1994, there were "do not eat" warnings issued for large mouth bass. From 2000 through 2004, that warning was reduced to limiting consumption of large mouth bass.

The Southern Florida Mercury Science Program is a collaboration of many agencies including the Florida Department of Environmental Protection, South Florida Water Management District, EPA, Florida Game and Freshwater Fish Commission, Florida Electric Power Coordinating Group, and the USGS. The research institutions for the Southern Florida Mercury Science Program are supported by the above-mentioned agencies as well as universities and industry.

The Florida Atmospheric Mercury Study established the significance of precipitation on mercury loading. In the time period from 1992 to 1996, rainfall and particulate samples were collected from across the State of Florida at nine tower sites and two ground sites. There is a strong seasonal pattern for mercury deposition in Florida—most of the rainfall and mercury deposition occur during the summer months of May through October. The observed mercury load was approximately 98 percent atmospheric.

The South Florida Atmospheric Mercury Monitoring Study conducted in 1995 and1996 was an intensive study on air in the Everglades, and consisted of the following:

- Stack tests for speciated mercury emissions form combustion sources (e.g., incinerators)
- Daily rainfall event collections at 17 sites
- Analyses for mercury species and other trace elements
- A detailed atmospheric model.

Strong spatial and temporal patterns provided evidence that local sources of mercury emissions, which were high in reactive gaseous mercury, contributed the most to the summer month mercury deposition. In addition, the chemical species of mercury had an effect on deposition.

The aquatic aspects that contribute to high mercury concentrations in fish are also important to consider. Biomagnification of mercury in fish is influenced by the water regime, food web dynamics, and the ecosystem habitat. Water level changes, nutrient loading, habitat changes, and mercury contamination are all interrelated. Monitoring and management of all of these aquatic aspects is vital for restoration of the Everglades.

In addition, benefits from mercury emission reductions can be seen at the local level within a few years after emissions reduction. For example, mercury levels in fish and wildlife in the Everglades have decreased 60 percent in the last 15 years after large decreases in mercury emissions occurred.

Mercury Cycling and Risk Management Recommendations on the Cheyenne River Sioux Tribal Reservation

Dale Hoff, with EPA Region 8, discussed the discovery of mercury-contaminated fish in ponds on the Cheyenne River Sioux Tribal Reservation, the sampling and analyses conducted to identify the source of the contamination, and the results of those tests. This RARE-funded project was initiated by the discovery of high mercury levels in fish inhabiting farm ponds during a Superfund site 5-year review on the Cheyenne River Sioux Tribal Reservation. The farm ponds contained mercury not associated with the Superfund Site source. The objectives of the project were to determine the source of the mercury contaminating the farm ponds, quantify patterns of mercury bioaccumulation in fish tissues, and make risk management recommendations to Tribal members to reduce mercury exposure.

Initially, groundwater was thought to be a potential source, as were inflow/overflow from watersheds and volatilization. Abiotic data were collected for atmospheric deposition, soils, sediments, surface water, and groundwater. Biotic data were collected for phytoplankton/zooplankton, macroinvertebrates, and fish. No elemental mercury was found in any of the samples; however, the data indicate that more than 95 percent of the mercury found in the fish tissue was in the form of methylmercury.

There are quite a few dams on the Cheyenne River Sioux Tribal lands, and most of these dams are stock dams (i.e., built for cattle). Because of the cattle, there is a large amount of organic material around the dams and associated ponds. A total of 50 surface and subsurface soil samples were collected at the locations of the nine ponds on the Cheyenne River Sioux Tribal lands. Atmospheric deposition, surface water, and groundwater sampling were also conducted. Analytical results indicated that the highest methylmercury levels were found in the surface water samples, and the percent of methyl mercury in surface water was almost identical to the percent found in phytoplankton samples. This is a very curious result.

To date, the source of the mercury contamination has not been identified. As a result of the data collection and testing, fish consumption advisories were issued. These advisories recommended that children 6 years of age and younger, women of childbearing age, and the elderly refrain from consuming fish from the Cheyenne River, Moreau River, Lake Oahe, and all of the surface waters on the Cheyenne River Sioux Tribal Reservation until instructed otherwise. Everyone else was advised to limit consumption of such fish to 16 ounces per month.

Tying It All Together: EPA Field Studies and Models Used in the Clean Air Mercury Rule

John Johnston, with NERL, discussed the studies and tools that provided the scientific data necessary to justify the Clean Air Mercury Rule, which was enacted on March 15, 2005. In order to impose a regulatory burden, EPA must be able to quantify the benefits of the burden. In the case of the Clean Air Mercury Rule, EPA needed to identify the benefits to human and ecosystem health of reducing mercury emissions by coal-fired utilities, and to provide a reasonable estimate for the timing and magnitude of various ecosystem responses to reductions in atmospheric inputs. There has been much research and modeling conducted to answer these questions.

Some of the watershed and water quality models used in support of the Clean Air Mercury Rule include the Watershed Characterization System, the Water Quality Analysis Simulation Program, Spreadsheet-based Ecological Risk Assessment for the Fate of Mercury, and the Bioaccumulation and Aquatic System Simulator. The Watershed Characterization System estimates loading to water bodies. The Water Quality Analysis Simulation Program utilizes gridded systems to create time series for water quality, and

is used after watershed characterization is complete to determine receiving water characterization (e.g., sediment burial, resuspension). The Spreadsheet-based Ecological Risk Assessment for the Fate of Mercury utilizes the best available science in its spreadsheet calculations; because of the many complications associated with mercury, it is important to have the data in a format that allows easy examination. The Bioaccumulation and Aquatic System Simulator provides full community simulations of persistent bioaccumulative toxics and is not limited to mercury.

The Spreadsheet-based Ecological Risk Assessment for the Fate of Mercury was developed to be process-based. Although initially developed as steady-state, it is now dynamic, and consists of a series of very detailed, linked modules whose results feed into each other. Inputs to this model include:

- Watershed information, such as location, area, and land use
- Lake hydrology information, such as area, epilimnion and hypolimnion depth, hypolimnion anoxia, and hydraulic residence time
- Lake water quality, such as pH, epilimnion, hypolimnion, air temperature, and annual precipitation
- Lake trophic status, including dissolved organic carbon and color
- Inflow mercury concentrations
- Total mercury contaminated sediments.

Based on the input values, this model provides estimates of aqueous and sediment mercury concentrations, mercury species, and fish tissue mercury concentrations; identifies the most sensitive species; and estimates the human and wildlife exposure hazard index.

A range of ecosystems across the U.S. were chosen to test the model framework, including Lake Barco, Florida; Brier Creek, Georgia; Lake Waccamaw, North Carolina; Lake Pawtuckaway, New Hampshire; and Lee Dam, South Dakota. The results of these tests indicate that geography is not an open predictor of how ecosystems will respond; watershed size, water body size, and depth are also important response predictors. Changes in residual mercury in fish tissue can be seen rather quickly following mercury reductions in the environment, but simplification of this to bioaccumulation overlooks the difference in size and age classes within species.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer session addressed a range of topics. These topics included: (1) speculations on why the percentage of total mercury found in invertebrates was lower than the percentage found in phytoplankton in the Cheyenne River Sioux Tribal Reservation; (2) the inclusion of sensitive subpopulations and socioeconomics in models; and (3) the availability of the Cheyenne River Sioux Tribal data.

Pathogen Challenges: New Pathogens, Old Pathogens but New Challenges

Following opening remarks by David Macarus, with EPA Region 5, seven speakers addressed pathogen challenges faced by EPA, chronic wasting disease, the Microbial Source Tracking Guide, the need for faster recreational water quality measurement devices, and collaborative monitoring efforts in New York City. An audience question and answer period followed the presentations.

Overview of Pathogen Challenges Facing EPA

Jafrul Hasan, with the Office of Science and Technology and the National Homeland Security Research Center, discussed the pathogen challenges currently facing EPA as well as future research needs to meet the challenges. The 1996 amendments to the SDWA require that EPA publish the CCL every 5 years; the CCL identifies unregulated contaminants that are known or anticipated to be present in water systems and that may require regulation. It is currently time to publish the second of these lists—the CCL-2, which includes pathogens, such as protozoa, viruses, bacteria, and cyanobacteria (algae) and their toxins. Although significant progress has been made in the CCL process, compiling the CCL is a continuous process and there are important data gaps that need to be addressed.

In addition to pathogens identified on the CCL, there are other emerging and re-emerging waterborne pathogens that EPA must address, including specific viruses, bacteria, and protozoa. For example, in the area of water security, EPA has the responsibility to protect the water infrastructure, and Homeland Security Presidential Directive #9 directs EPA to develop robust, comprehensive, and fully coordinated surveillance and monitoring systems to provide early detection and awareness of water contamination. In response to this, the Office of Water and the National Homeland Security Research Center are collaborating in the development of the WaterSentinel Initiative. This demonstration project will design, deploy, and evaluate a model community water system for drinking water security.

Much water security work has been completed, there remain many research needs. Some of the priority water security research needs for EPA include:

- More data on occurrences of pathogens in public water systems and treatment effectiveness
- Rapid, sensitive, and specific detection assays that are capable of determining viability and infectivity
- Advanced treatment and disinfection techniques
- Alternate microbial indicator systems
- Collective health risk of opportunistic bacterial pathogens in biofilms
- Guidance to establish microbial ambient water quality criteria for recreational water, shellfish harvest water, and drinking source water
- Evaluation of various wastewater treatments for CCL-2 pathogens.

Existing gaps in water security research include data standardization; real-time, non-specific contamination warning systems for early detection in drinking water distribution systems; and real-time, contaminant-specific warning systems.

Chronic Wasting Disease: Treatment and Disposal of Solid Wastes and Wastewater

Fran Kremer (with NRMRL), Susan Mooney (with EPA Region 5), and Wendy O'Brien (with EPA Region 8), discussed chronic wasting disease, the scope of the problem, treatment and disposal issues, and existing research data gaps to address the disease. This project was funded by a RARE grant and other private sector and association funds.

Chronic wasting disease is a fatal, degenerative central nervous system disorder found in deer and elk, and is related to Mad Cow Disease. Chronic wasting disease is a member of a larger family of diseases called Transmissible Spongiform Encephalopathies, which are believed to be caused by an abnormally folded version of a normal cellular protein known as a prion. Because of its long latency period, symptoms may not be seen for years and this can lead to unknowing transmission of the disease.

Chronic wasting disease is typically transmitted horizontally, through ingestion of contaminated soil, and can survive for long periods in the environment. Currently, there is no evidence of chronic wasting disease transmission to humans. However, that may be due to the fact that we do not have the tools to monitor for chronic wasting disease in humans, and fate and transport mechanisms of the disease are uncertain. Better methods are needed to detect and quantify prions in environmental media. Chronic wasting disease has been found in 23 states across five EPA Regions.

Treatment and disposal approaches for Transmissible Spongiform Encephalopathies include rendering, landfilling, alkaline hydrolysis, and thermal techniques. Rendering provides safe reduction and waste stabilization, destroys pathogens, and can achieve a 60 percent reduction in mass. The three key processes of rendering are size reduction, cooking, and pressing, and size reduction reduces the effectiveness of the prion. Because the product of rendering is very stable, the process affords more time and latitude in making decisions regarding disposal. However, there is a need for collaboration between the rendering research activities and the rendering equipment manufacturers to optimize the process.

Landfilling was cited in draft interim practices guidance, issued last year by OSWER, as the most reasonable, but not preferred option of chronic wasting disease disposal. Current landfill research is assessing the fate and transport of prions in a landfill environment through batch, column, and infectivity tests. Preliminary assessment results indicate that prions are preferentially sorbed to negatively charged soil constituents, moisture enhances the movement of prions, and lower pH enhances retention. Collaborative efforts are underway with the United Kingdom to improve the modeling approach. Landfill research needs include optimization of landfill barriers as well as fate and transport modeling.

Alkaline hydrolysis uses high temperature and pressure in conjunction with alkali to break down proteins, fats, and other molecules. The process results in two waste streams—an aqueous solution rich in amino acids and calcium phosphate. Initially developed for hospitals for disposal of medical waste, the processing units (called digesters) have been used by a number of agriculture schools and can process up to nine deer at a time; mobile units can process four or five deer at a time. These digesters are highly effective, but involve large capital costs. There is also the issue of disposing of the liquid waste stream because some publicly owned treatment works will not accept it. Alkaline hydrolysis research needs include optimization of operational conditions, determination of destruction effectiveness, and process scale-up evaluation.

Thermal treatment processes for chronic wasting disease include open burning, air curtain destructors, waste-to-energy facilities, medical and hazardous waste combustion facilities, gasification, and alternative technologies such as pyrolysis/plasma. Extreme conditions are required to destroy prions. The United Kingdom recommends incineration at 850°C for 2 seconds, and the USDA recommends a minimum fuel loading per carcass. The issue with the waste-to-energy process is that industry does not want this material in their infrastructures. Thermal technique research needs include methods to evaluate air emissions and ash to assure total prion destruction, air/fuel requirements for animals of different sizes and species, and operating conditions that minimize potential cross-contamination.

Current research on the fate of prions in wastewater systems involves the assessment of prions in wastewater and biosolids in publicly owned treatment works, as well as the fate of prions in wastes being handled by analytical laboratories. Preliminary extraction protocol study results indicate that while the

activated sludge technique seems to be optimized, the anaerobic sludge technique needs work. Preliminary detection study results indicate that the majority of prions are found in biosolids, as opposed to the effluent. Future research needs include optimization of extraction conditions, development of enzyme-like immunosorbent assays for sludge samples, sequential batch incubation, and septic sludge batch incubation.

The EPA Microbial Source Tracking Guide Document

Mark Rodgers, with NRMRL, discussed the Microbial Source Tracking Guide, which is the product of collaborations between ORD, Office of Water, USGS, NOAA, USDA, Environment Canada, regional and state scientists, and scientists in academia. The intent of the Microbial Source Tracking Guide is to match microbes from a polluted site with an animal source to suggest the origin of the fecal pollution. This is based on the idea that the intestinal microbes found in different animal groups are also expected to be different due to each animal group's unique gut conditions (e.g., temperature, diet, and digestive system) and natural selection (e.g., space, nutrients).

The Microbial Source Tracking Guide is intended to walk the user through the different methodologies that have been explored. Methods can be qualitative, quantitative, genotypic, phenotypic, and library dependent or independent; the term library refers to a collection of reference isolates (usually from fecal sources). Library independent methods include phage typing, gene-specific PCR, total community analysis, and host-specific PCR; the use of PCR is anticipated to aid in finding biomarkers that will be unique to the host animal. Library dependent methods include antibiotic resistance analysis, pulse field gel electrophoresis, and ribotyping; these types of methods tend to provide the user with a fingerprint or profile of each isolate. The methods in the Microbial Source Tracking Guide are being offered to the EPA Regions and states, but there are a number of questions that need to be answered before any of the methods are applied.

Microbial source tracking methods are useful as supplements to sanitary surveys and for risk analysis. As a supplement, example applications include the identification of beach contaminant sources and TMDL violations. Used in risk analysis, the methods can compare the humans versus animals and domestic animals versus wildlife; only in the last decade have the tools existed to try to distinguish sources of fecal pollution.

The Microbial Source Tracking Guide is needed as a result of the recent proliferation of new methods (e.g., genomic, phenotypic, cultural, noncultural) with different levels of discrimination, as well as the fact that the most useful method depends upon the circumstances. The choice of method to use needs to be considered carefully and should be based on the questions to be answered about a system or watershed.

The Microbial Source Tracking Guide, anticipated for release in June 2005, contains seven chapters that address decision criteria, microbial source tracking approaches, data collection and analysis, performance standards, assumptions and limitations, and applications of microbial source tracking approaches. Because technology is changing rapidly, the document is meant to be amended as new information becomes available.

The NEEAR Study: Can Faster Methods of Measuring Recreational Water Help Prevent Swimming-Associated Illness?

Tim Wade, with NHEERL, discussed the NEEAR study of beach contamination and methods to more quickly provide analytical results for decisionmaking. Since the 1950s, swimming in water contaminated with fecal material has been linked to adverse health effects. Studies conducted in the 1970s and 1980s in marine fish and fresh water served as the basis for current recreational water guidelines recommended by

EPA. Current measurement methods require 24 to 48 hours to obtain results, and this presents a problem for timely beach management decisions. The purpose of the NEEAR study is to answer the question of whether an association exists between illness and recreational water quality, and potential applications of new, rapid methods of determining water quality.

The NHEEAR study criteria required a Great Lakes Beach, a human sewage point source, an ample number of beach goers to support the study, and variability in water quality. The study was designed to collect water samples at the beach on summer weekends. The target population included all beach goers. After providing a household water sample, every study participant was interviewed three times: upon enrollment, while at the beach, and 10 to 12 days after the beach interview. Water samples were collected three times daily at two depths. The water sampling points covered the majority of the area where beach goers were swimming. Observed health outcomes included gastrointestinal illness, upper respiratory illness, skin rash, eye irritations, and earache.

The new method for measuring water quality must be quantitative and rapid—providing results in less than 2 hours. QPCR may be an option, and is a DNA-based technology that does not require a viable organism. Fluorescent antibody-based methods and pharmaceuticals have also been considered. However, EPA Method 1600 is currently the recommended method for modeling.

The NEEAR study utilized regression modeling. Because it was an observational study, potential biases had to be identified to determine the risk of getting in the water. A continuous water quality indicator measured exposure. Data were collected at four beaches from a total of 21,015 individuals. The study results indicated that swimmers had a 1.5 times higher risk of contracting gastrointestinal illness than non-swimmers. The risk for skin rash and earache were also higher for swimmers. The results also indicated a strong association between *Enterococcus* and gastrointestinal illness in children. Non-swimmers reported the lowest number of illnesses. In the next stage of the study, data will be collected at marine beaches in the summer of 2005.

Control of the West Nile Virus in New York: Collaborations of EPA Region 2, CDC, and New York City Department of Health

Michael Kramer, with EPA Region 2, discussed the EPA Region 2 Ambient Sampling Monitoring Program. The objective of this program is to determine the impact of adulticide applications on sensitive water bodies (as defined in CWA Section 309) to control mosquitoes that may carry West Nile Virus, and the levels of pesticide residues within the application perimeter.

The study methodology included comparison of pre- and post application sample results, recording sampling locations on a global positioning system, and setting a specified post-application period for sample acquisition. An approved quality assurance project plan was required and had to include the number of samples to be taken, sampling objectives, monitoring parameters, procedures, and quality assurance/quality control measures. Sample handling procedures required notifications prior to spray events, sampling point selection prior to pesticide application, and recording the time of application. Samples were collected 48 to 72 hours after the pesticide was estimated to have reached the sampling point. Sample analysis was conducted in an EPA Region 2 laboratory. Duplicate samples were analyzed as part of standard laboratory operating procedures to ensure precision and accuracy.

Analysis results indicated that for the years 2001 through 2004, the number of samples taken in New York City that exceeded the detection limit for resmthrin, sumithrin, and piperonly butoxide decreased dramatically. However, the number of samples taken in New Jersey from 2003 to 2004 that exceeded the detection limit for malathion increased.

Project participants included:

- EPA Region 2 Pesticides Team, Monitoring and Assessment Branch, and laboratory
- CDC, New York Office
- New York State Department of Environmental Conservation
- New York City Department of Health and New York City Office of Emergency Management
- New Jersey Department of Environmental Protection, Office of Mosquito Control Coordination
- New Jersey county mosquito control agencies.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These topics included: (1) the impact of the West Nile virus on humans and animals; (2) correlation of efficacy with a water body; (3) explanation of why children are more susceptible to illnesses from swimming than adults; (4) the correlation between QPCR and culture data; (5) the possibility that children are infecting one another in a water body; and (6) the timeframe for using source tracking tools and epidemiological studies at beaches.

Restoration Actions and Salmon Productivity in Pacific Northwest Watersheds

Following opening remarks by Derek Poon, with EPA Region 10, three speakers discussed efforts to monitor watersheds, link watershed conditions and salmon population declines, and salmon response to habitat restoration actions. An audience question and answer period followed the presentations.

Linking Human Actions to Salmon Productivity: Intensively Monitored Watersheds

Robert Bilby, Chief Environmental Scientist with Weyerhaeuser Company, discussed background information on the need to monitor watersheds in the Pacific Northwest as a means to address declining Pacific salmon populations. There are five species that have the word salmon in their name, but the scope of the study has been broadened to include a few more species. In the 1990s, there were relatively few wild salmon left in the Pacific Northwest. Under the Endangered Species Act, salmon status is evaluated using Evolutionarily Significant Units. NOAA designated 52 such units in California, Oregon, Washington, and Idaho, and 30 are listed or are being considered for listing under the Endangered Species Act—5 endangered, 22 threatened, and 3 areas of concern.

Factors controlling salmon abundance include natural variation and human impacts. Natural variation includes climate (e.g., temperature and precipitation) and ocean conditions, such as cyclical changes; both of these variables have a huge impact on salmon survival. Human impacts include habitat destruction/restoration, harvesting practices, hatcheries, and hydropower utilities.

The Intensively Monitored Watersheds Program is currently examining freshwater habitats. Salmon habitat restoration efforts are widespread in the Northwest region and include regulatory changes as well as deliberate manipulation of habitat. To date, billions of dollars have been spent on restoration and protection efforts with the expectation that the number of returning adult salmon will increase. However, there is little evidence to support that the efforts have been effective.

The relationship between freshwater habitat conditions and salmon abundance is difficult to quantify, and the problem may be due to variation. Variations other than habitat can have an impact on survival. Salmon require a variety of habitats to complete freshwater rearing. The salmon have to be in the right habitat at the right time to survive. For example, the Coho salmon hatches in the spring in channel

margins, migrates into head water tributaries, and then into floodplain habitats and wetlands. Their bodies undergo shape, color, and physiological changes to adjust to the different habitats. After spending 18 months in salt water, they return to the streams to spawn. The lack of long-term data sets is also a problem.

The concept behind the Intensively Monitored Watersheds Program is that the quantification of salmon response to habitat actions requires assessment at the appropriate scales of space and time. Therefore, the Program will:

- Conduct long-term, paired-watershed experiments
- Use experimental units large enough to encompass all habitat types required for the fish to complete freshwater rearing
- Conduct assessments at multiple spatial scales from stream reach to whole watersheds
- Coordinate assessments across scales
- Focus on steelhead, Coho, and cutthroat species in small watersheds
- Address Chinook salmon in two large watersheds.

The ultimate goal of this Program is to be able to connect what is going on at the project level with what is going on at the watershed level. Study locations include the Strait of Juan de Fuca Complex, the Skagit Estuary, the Hood Canal and Lower Columbia complexes, and the Wenatchee River basin. This is a collaborative effort involving Washington State agencies, federal agencies, tribes, and private industry. In kind contributions make up 50 percent of the funding support. Total program expenses are approximately $2 million per year.

William Ehinger, with the Washington Department of Ecology, discussed the design of the Intensively Monitored Watersheds Program, which includes before and after assessments on both controlled and impacted areas, hierarchical monitoring schemes at different spatial scales (reach, sub-basin, and basin), and hypothesis-driven monitoring and research. The reach-scale monitoring will assess the effects of specific restoration actions, sub-basin-scale monitoring will assess the effects of multiple restoration actions, and basin-scale monitoring will assess the effectiveness of all actions.

A baseline for the small watershed studies was established and included smolt production, spawner counts and distribution, summer juvenile fish abundance, habitat information, flow, temperature, and water quality. Establishing this baseline will allow us to determine if production is increasing, but it will not aid in determining why production is or is not increasing. The hypothesis-driven monitoring portion of the study was designed to understand the mechanisms affecting smolt production.

Results from a study of Big Beef Creek in the State of Washington showed a lot of variability in the production rates, as well as an extended period of low productivity. The results also suggested a strong relationship between smolt production and flow. Future work at this site will focus on quantifying the relationship between November peak flows and spawner distribution, and the relationship between summer low flow and summer rearing habitat.

Another study area involves the Straits of Juan de Fuca Complex, which has a well-documented history of degradation. The primary salmon species in this area are Coho salmon and steelhead trout. Mass wasting is the biggest driver of habitat degradation. Severe mass wasting in this area is attributed to landslides

associated with harvesting practices, railroad logging, fires in the lower watershed, road construction, clear cutting, and a 1989 flood event. As a result of this mass wasting, the stream habitat is poor. There is widespread sediment deposition on the lower basin areas and low quantities of woody debris throughout the basin. The poor quality of the rearing habitat has led to a decrease in the number and volume of pools, resulting in an overall reduction in the quality and quantity of spawning habitat. The proposed restoration plan for the Straits Complex includes:

- A reduction in the landslide rate to pre-disturbance levels
- Restoration/management of riparian forests towards late successional condition for conifers
- An increase in in-channel large woody debris
- An increase in connections between habitat types (e.g., off-channel/barriers).

Christopher Jordan, with NOAA, discussed studies of large watersheds containing Chinook salmon. Because of their large size, Chinook salmon have traditionally been the most important commercial species in the Pacific Northwest, and they use much larger watersheds. It is much more difficult to treat large watersheds than to treat the small ones. Two examples of where the intensive watershed monitoring concepts are being applied are the Skagit River Estuary and the Wenatchee River Basin.

The Skagit River Estuary is a critical rearing area for ocean-type fish; the salmon species rear in the summer and then migrate to the ocean. This migration is considered the rate-limiting step. Comparison of historic and current estuary maps shows a 72 to 80 percent habitat loss. A large number of restoration projects are underway to open up more of the channels and off-channel habitats. It is believed that restoration of this area will add more diversity in how the fish interact with the habitat and will have an effect on increasing the fish population.

At the Wenatchee River Basin, monitoring is being conducted spatially as it is being done in the small watershed studies. The idea is to use what is known about the landscape to restrict monitoring efforts. The sampling sites in the Wenatchee River Basin are much farther apart than the small watershed habitats, and this adds another spatial element to the study. These intensively monitored watersheds are only fractions of the entire population.

The overall objective of the Intensively Monitored Watersheds Program is to provide tools for recovery of endangered salmon species across the entire Pacific Northwest, not just the watersheds being studied. Salmon management results are expected in three to five generations, but restoration planning results are expected in 1 to 3 years. This Program will continue to expand the scientific experimental approach to restoration evaluation, and the collaborative approach to restoration design, implementation, and evaluation.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These topics included: (1) the use of woody debris in restoration efforts; (2) setting boundaries to calculate similarities; (3) applying the intensive watershed monitoring study concept to different biological starting points; (4) the contribution of dead fish to stream nutrient loads; (5) the possible ability to correlate spikes in agricultural chemicals affecting salmon development by overlaying discharge permit and other data onto the maps; and (6) the focus of restoration efforts on streams that were productive for salmon and have been damaged by human activity as that is greater benefit than restoring streams that did not originally support salmon.

Using Landscape Tools to Assess Vulnerability

Following opening remarks by Brenda Groskinsky, with EPA Region 7, two speakers discussed the use of landscape tools to assess the vulnerability of water quality in the Upper White River Basin. An audience question and answer period followed the presentations.

Use of Landscape Tools for the Upper White River Basin

Jaci Ferguson, with EPA Region 7, discussed the need to develop a landscape analysis tool to use in the Upper White River Basin to address issues of increasing pollution in the Beaver, Table Rock, Taneycomo, and Bull Shoals Lakes. This project involves two states, Missouri and Arkansas, located in different EPA Regions (6 and 7). This presents a challenge in dealing with political issues in each state and two different mindsets regarding priorities.

The White River Basin, located in the Ozark Mountains, over 2 million acres in size with a population of over 1 million. This is one of the fastest growing areas in the nation, and this regional growth (from development, tourism, and agriculture) is causing stress on the water quality. As a result, a lot of work will have to be done to preserve the beauty of the area. Topsoil is minimal and there is a lot of fractured limestone in the area; this has a large impact on surface water flow and provides much interconnectivity between groundwater and surface water.

Lake Taneycomo is actually a river that receives its source water from a hydroelectric dam in the nearby community of Branson, and the dam is controlled by USACE. The water quality in the river varies depending on how much water is allowed to flow through the hydroelectric turbines and into the lake. Lake Taneycomo was supposed to be a trout stream; however, trout prefer water with high dissolved oxygen content and the trout in the lake are very stressed because there is not always adequate dissolved oxygen content. The amount of dissolved oxygen available for the trout depends upon the season, how much water is in the reservoir, and how much water USACE will release into the lake. Currently, there is a lot of negotiation and discussion between the fish and game commissions in Missouri and Arkansas, the USACE, and environmental agencies in an effort to maintain a minimum flow through the river. Because water flowing through the turbines is often considered a waste of money if the water is not being used to generate electricity, many policymakers view this situation as an economic issue.

Bull Shoals Lake has a vast shoreline, which makes it ideal for the development of lakefront homes. There is a lot of forest in the area, but it is being cut down. One of the major issues with the shoreline homes is that they use septic tanks, which are often inadequate and overflow. Although the seepage is not seen on the ground, it is showing up on shoreline limestone because the seepage flows through the fractures in the limestone and takes the path of least resistance to the lake. Recently, there have been many efforts to educate the lakefront communities about this problem. Also, there is a project underway in the community of Bradleyville to try to solve this problem. The Bradleyville has 40 homes—all with their own septic tank. Because it is too expensive to install a sewer treatment line, this project will connect all of the household septic tanks to a decentralized effluent treatment system to remove nutrients from the effluent and minimize pathogens. A lot of monitoring is being done to see if this is having an impact.

The White River Basin is home to five major poultry industries, resulting in approximately 1 million tons of poultry litter each year. The problem is that poultry litter contains the highest amount of phosphorous of any kind of livestock manure, and the streams in the Ozark area are turning green from an overgrowth of algae. In order for algae to flourish, it needs sunlight, nitrogen, and phosphorus, and the phosphorus is the limiting factor. However, there is a competing interest in that poultry litter is also an excellent fertilizer that can support cattle farming.

Tourism is also a stressor on water quality. For example, the town of Branson averages 6 million visitors annually. Table Rock Lake is home to many fisheries and hosts numerous trout tournaments. Tourism, development, and agriculture are all competing entities that are all highly dependent on good water quality. There is a need to develop a way to balance the economic and environmental aspects of the problem with limited resources, people, and time.

Water Quality Vulnerability in the Ozarks: An Ongoing Assessment of the Upper White River Watershed

Ricardo Lopez, with NERL, discussed the development of water quality indicators to assess water quality vulnerability in the Upper White River Basin. The goal of this project is to conduct a watershed analysis using a broad-scale landscape ecology approach, existing stream sampling data, satellite remote sensing data, GIS, and field verification. Accuracy assessment is a very important part of this process for developing indicators.

This project built upon work conducted by EPA Region 6 in 2002 and 2003 under another RARE-funded project. The focus of that project was on habitat vulnerability, but a portion of that project examined water quality vulnerability using existing data sets throughout the entire White River Basin. The results of that project are presented in an EPA report (EPA/600/R-03/057) in the form of a landscape atlas.

In the early stages of the EPA Region 6 project, a comparison of some basic forest metrics data and existing water quality data showed that forest loss could be a good indicator of increased nutrient and sediment loadings in streams. There are 38 National Water Quality Assessment Program sampling sites in the White River Basin. However, the distribution and number of water quality sampling sites does not lend itself to the kind of broad-scale analysis needed. Additional studies that examined the influence of the presence or absence of forest on riparian vegetative areas also showed a correlation between the loss of forest and an increase of nitrogen and phosphorus loading in streams.

For this project, an approach was needed that would provide a much more powerful capability for statistical analysis. To do this, the water quality vulnerability indicator development process was broken down into three main topics: landscape metrics, water quality data, and ecological concepts. Using landscape metrics saves a lot of time, but a better approach may be to first what questions to answer and develop the metrics later. Project activities are trying to address agricultural activities (e.g., poultry farming), population increase (e.g., urbanization), topography, and hydrography, and determine how these are related to water quality. Water quality data includes nutrient, metals, salts, sediment, and bacteriological information. These five parameters may be affected by changes in land cover or land use and may be evaluated using spatial or temporal statistical analyses. Throughout all of these activities, it is important to keep in mind the ecological concepts that are likely to exist in this part of the country to determine where water quality may be impacted and where water quality may not be impacted. So the goal is to deliver a practical product that will be useful while using ecological theory.

Mapping landscape metrics is difficult because nested watersheds are being examined. When the analysis product is delivered, the browser will be designed so that the user can access information on each of the sub watersheds and their characteristics. EPA Region 6 has very good USGS water data from 244 locations throughout the Upper White River Basin, and this field data will be used to test the metrics that will be used to develop the landscape indicators and a useful map.

Water quality vulnerability indicator candidates include chicken production metrics, agriculture/grassland on slopes, agriculture/grassland in riparian areas, and percent forest in riparian areas. Efforts are underway to conduct testing of these candidate indicators with the field data, and a particular challenge is that existing data sets are not always updated. This is particularly true for the chicken production metric

because chicken production facilities are not well mapped. Therefore, work has been done to edit the existing mapping data (using remote sensing data) to derive some of the generalized statistics at a watershed scale. This method seems to be one of the newer ways of examining the potential contribution of chicken production facilities to surface waters. Currently, several metrics related to the poultry production facilities are being run on this generalized watershed scale.

The agriculture/grassland on slopes metric includes pasture, row crops, and golf courses. Work is being conducted to compare the metric with the field data to determine if it is a good indicator of water quality.

In addition, rates of change over decades can be examined using field data and GIS remote sensing data, percent forest within riparian area has shown promise as an indicator in the aforementioned study by EPA Region 6, and efforts are underway to examine the use of temporal change metrics as potential indicators of water quality, which would be very helpful in future scenario building.

The product of this project, a CD browser, is expected to be available in the fall of 2005, and is meant to be an accessible version of the product (a book of maps) delivered to EPA Region 6. The browser will be linked to the EPA web site and will contain background information on the Upper White River Basin region, overview sections, area photos, and PDF maps. The CD can be distributed on the local municipality scale and the beta version will eventually be distributed to EPA regional partners.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These topics included: (1) methods for counting the number of chicken houses in the White River Basin Area; (2) attribution of a specific percentage of change to a specific metric; (3) drawing conclusions between water quality and specific metrics; (4) establishing boundaries in units of measurement; (5) development of boundary maps; (6) the addition of streams to the water quality vulnerability CD browser; (7) plans for educational and outreach programs; (8) the importance of the work addressing the needs of the customer; and (9) coordination efforts between regions.

More than Just Hot Air: Collaborative Approaches to Cleaning Up Air Toxics Locally

Following opening remarks by Mike Callahan, with EPA Region 5, four speakers addressed the challenges involved in dealing with air toxics, dioxin, and PM air emission characterization studies, emission characterization using remote sensing technology, and linking air toxics to human health effects. An audience question and answer period followed the presentations.

Challenges of Air Toxics

Deirdre Murphy, with OAQPS, discussed challenges faced by EPA in addressing air toxics. In this discussion, the term “air toxics” refers to the 188 pollutants listed by the CAA as air toxics, rather than criteria pollutants under NAAQS. Lead and PM (e.g., diesel exhaust, metals, PAHs, dioxins) happen to fall into both categories.

The 1990 amendments to the CAA spelled out a two phase approach for dealing with stationary sources. Phase one involved the implementation of technology-based controls on major sources of air toxics. This included 96 standards covering 174 source categories over 14 years. Phase two mandated the development and issuance of a risk-based rulemaking for sources posing residual risk. The first rule under phase two addressed coke ovens and was issued on March 31, 2005. It is expected that there will

be seven more final decisions made in 2006 with the rest of the decisions expected to be made between 2006 and 2012.

Additional stationary source requirements have come from the National Research Council Report issued in January 2004. This report recommended five areas for improvement, including the strengthening of scientific and technical capacity, developing an integrated program for criteria and hazardous air pollutants, and enhancing protection of ecosystems and public welfare. Following the release of that report, assistance was sought from the Clean Air Advisory Committee to help with implementing the new recommendations. In response, the Clean Air Advisory Committee issued a report in December 2004 containing recommended short-term actions, and deliberations are underway for longer-term actions.

One challenge for the Air Toxics Program is to improve communication of what has been achieved and what is hoped to be achieved. Another challenge is to devise comprehensive air pollution strategies that integrate air toxic and criteria pollutants and consider benefits achieved from other reductions. In general, there is a need to prioritize actions, focus attention on the highest priorities through innovative approaches, keep the data current with the science, and keep the emerging toxics program current.

To date, progress in the Air Toxics Program includes the following:

- Completed standards for major stationary sources that will eliminate nearly 1.6 million tons per year of toxic air emissions
- Mobile source standards implemented between 1996 and 2010 that will eliminate an additional 1.1 million tons per year of toxic air emissions
- Work with communities to address hot spot issues
- Future stationary and mobile source decisions.

Getting Some Air Time: The Challenges of Air Toxics

Sean Hogan, Chief of the Technical Support Office in EPA Region 9, discussed the challenges faced by EPA Region 9 regarding air toxics, which are much worse than other areas of the U.S. PM and ozone are particularly problematic in EPA Region 9, and the meteorology contributes to these problems; for example, in some areas, the meteorology contains the pollution to the source area.

PM comes in two forms, PM2.5 and PM10, both of which are problems in EPA Region 9. The San Joaquin Valley and Los Angeles have significant PM2.5 issues; however, PM10 is a unique problem for EPA Region 9. The only places where there are spikes of PM10 are in California, Imperial Valley, Phoenix, Las Vegas, and the San Joaquin Valley. Urbanization (i.e., large house construction) created large amounts of PM, and these sources contribute to the huge dust storms prevalent in these areas. Dry lakes also contribute to the PM problem.

A priority for EPA Region 9 is to obtain better emissions data for input into the Region's databases and to develop accurate emissions data by reducing uncertainty. The ultimate goal is to examine all of the pollutants in the Region in real-time.

The San Joaquin Valley has multiple metropolitan areas, many mobile sources, significant amounts of wood burning, and widespread agriculture and dairy industries. Wood burning contributes PM, dioxins, and other air toxics to the atmosphere. In addition, organic gases from the agriculture and dairy industries contribute to ozone and ammonia from these industries contributes to PM. EPA Region 9 is trying to

better understand the types, sources, and constituents of emissions for dairy farms and wood burning in order to gain a better understanding of where to place controls.

EPA Region 9 air toxics efforts receive funding support from ORD, which has a wide array of research mechanisms that are useful and relevant. One example involves a RARE grant to conduct emission studies. One of these studies, in collaboration with NASA, evaluated jet aircraft to determine emission factors and the effect of fuel properties and engine operating conditions on emissions. The Los Angeles International Airport is the fifth largest airport in the country and has many surrounding communities. Because airports have many emissions, determining the source(s) of emissions is a challenge. Another RARE grant project involves the evaluation of dioxin emissions from wood stoves, and the STAR Program provided funding to develop urban air toxic strategies and to conduct air studies on the effects open-air rice burning.

Characterizing Air Emissions through ORD's RARE Program

Sean Hogan, Chief of the Technical Support Office in EPA Region 9, discussed why accurate air emissions data are critical, and the use of ORD's RARE Program to conduct studies on dioxin emissions from wood stoves and emissions from commercial aircraft. The National Emissions Inventory was created in 1999 to maintain emissions data for criteria pollutants and hazardous air pollutants. Criteria pollutants include carbon monoxide, NOx, SO_2, PM, ozone, and lead; there are 188 hazardous air pollutants. The National Emissions Inventory includes emission estimates for major sources as well as county-level estimates for area, mobile, and other emission sources. These data are used for air dispersion modeling, regional strategy development, regulation setting, air toxic assessments, and tracking trends in emissions over time. Tracking over time is going to become more and more important in gauging the success of our program.

The Bay Area Air Quality Management District used EPA's emission factors to estimate that residential wood combustion accounts for approximately 38 percent of the dioxins emitted in the San Francisco Bay area. The National Emissions Inventory emission factor of 2 ng toxic equivalency (TEQ)/kg of wood was based on two European studies. Since the data from these studies was hard to use, EPA Region 9 conducted its own study. In 2001, EPA Region 9 submitted a proposal to the RARE program to evaluate emissions from residential wood combustion. This study was important to EPA Region 9 due to the significant amount of wood burning in the region, especially in the San Joaquin Valley. Before the study, there was limited data available on dioxin, PM, and PAH emissions from residential fireplaces and woodstoves. This study was crucial since the topography and inversions in this region exacerbate PM concentrations. The study also has possible relevance to wildfire emissions. During the study, emissions were sampled from the flue of a woodstove and a fireplace. Materials tested were oak, pine, and artificial logs. Results indicated that the artificial logs produced the highest amounts of dioxin and overall pollutants of all of the types of logs tested. Other results of the study included:

- The average polychlorinated dibenzodioxins and dibenzofurans ranged from 0.25 to 1.4 ng TEQ/kg of natural wood logs burned, and from 0.25 to 2.4 ng TEQ/kg of artificial logs burned

- PM emission factors range from 2 to 13 g/kg of wood, depending on fuel type and appliance. Greater than 99 percent of the PM emitted is PM2.5.

EPA Region 9 utilized another RARE grant in 2002 to characterize PM2.5 and air toxics emissions from commercial aircraft in collaboration with NASA. Project objectives were to develop PM2.5 emission factors (indices) and chemical source profiles for a representative Boeing 757, CFM56 aircraft engine; compare the emission factors and source profiles obtained at the 1 meter exit location using artificial dilution to those obtained in the plume at 30 meters with natural dilution; and determine the effect of fuel

properties and engine operating conditions on the emissions. To date, three EPA tests have been conducted at NASA's Dryden Flight Research Center using two different types of fuel. Tests were conducted for airport approach, idling, climb-out, and take-off conditions. Samples collected from these EPA tests were analyzed for PM2.5, mass particle size distribution, elemental and organic carbon content of the PM2.5, PM2.5 elemental and ion analyses, particle- and gas-phase semi-volatile organic analyses, and gas-phase volatile organic carbon, HAP, and carbonyls. NASA conducted six additional tests—two tests for three different fuel types (base fuel, high sulfur fuel, and high aromatic fuel). All six of the NASA tests were conducted at steady-state power conditions. Full results of this study are expected in June 2005, with scientific journal publication expected in 2006.

Collaborative Approaches Using Remote Sensing

Barry Feldman, with EPA Region 6, discussed the use of remote sensing to identify, characterize, and manage air emissions. Given the increase in facility inspection responsibilities, environmental monitoring needs, their associated costs, and the decrease in resources, agencies have been prompted to investigate innovative processes to meet their needs. Remote sensing has the capability to identify emissions that may not be part of current emissions inventories.

In 2003, Congress mandated that EPA "*…develop a 'one-stop-shop' office to coordinate similar programs which foster private and public sector development of new, cost-effective environmental technologies*." In response to this, EPA established an Environmental Technology Council. Of the 40 different categories of technologies proposed to the Environmental Technology Council, remote sensing received the most votes and was chosen to be adopted by the Remote Technology Project. EPA Region 6 is co-chair of the Remote Sensing Work Group, which involves more than 30 people. Some of the challenges are that the technology is expensive and few people are trained in its use.

EPA Region 6 has a particular interest in hyperspectral imaging. This type of technology allows for the testing and characterization of chemical compounds, and it provides a "big picture" without having to rely on point source monitoring to identify problems. Demonstration projects utilizing this technology are funded through RARE and the Regional Geographics Initiative. Hyperspectral imaging projects undertaken by EPA Region 6 include:

- PlumeEx – a look at air quality problems in the Houston area
- Houston Ship Channel – looking at anomalies in the ship channel
- Smart LDAR – working with the petrochemical industry to develop better leak detection methods
- Cajun Cloud – thermal imaging for detecting industrial emissions in Baton Rouge, Louisiana
- Regional Haze – the use of satellite information to study the affects agricultural burning in Mexico has on regional haze issues.

Participants in the PlumeEx project included EPA, Texas Commission on Environmental Quality, Harris County Pollution Control, DOW Chemical Company, and the U.S. Air Force.

Setting Priorities by Linking Modeled Air Toxics Concentrations to Community Health Effects

Jeff Yurk, with EPA Region 6, discussed some of the actions that EPA Region 6 is taking to link toxic emissions to human health effects and collaborative activities with CDC. EPA Region 6 is the home of

the nation's petrochemical industry, and 100 million pounds of air toxics are released annually in this region from more than 200,000 point sources. EPA Region 6 also houses one-third of the nation's hazardous waste combustion facilities. It is estimated that approximately 50 percent of toxics released are not reported, and people want to know if the air they are breathing is safe.

Some of the actions being taken by EPA Region 6 to link air toxics and human health effects include the following: conducting prioritization modeling, examining cancer clusters, and collaborating with CDC on epidemiology studies. Two EPA models being investigated for prioritization purposes include the National-Scale Air Toxics Assessment model and the Regional Air Impact Modeling Initiative model. The National-Scale Air Toxics Assessment model provides data on a tract level, while the Regional Air Impact Modeling Initiative model provides data on a community level.

The Regional Air Impact Modeling Initiative model is used to prioritize which sources to focus on. Data indicate that most emissions come from fugitive sources on the ground. There is a lot of information contained in emission databases, but it is necessary to prioritize efforts to address the emissions issues first with the source facilities. If they are not cooperative, then the next steps are enforcement.

A cancer cluster study is examining cancer incidence and mortality rates within specific zip codes. The purpose is to look for abnormalities in the rates found in one geographical area by comparing poison distribution at a certain confidence level. Examples of prioritized chemicals associated with certain cancer types include benzene (associated with leukemia, lung, and oral/nasal cancers), 1,3-butadiene (associated with leukemia, lymphomas, lung/bronchus, liver, and bladder cancers), formaldehyde (associated with nasal, pharynx, Hodgkin's lymphoma, liver, leukemia, and kidney cancers), and hydrazine (associated with leukemia, liver, lung, and nasal cancers). Although informative, cancer cluster studies have their limitations. Data availability and resolution are issues because requests for data can take several months to process, and the zip code level is the finest level of detail that can be attained. Privacy issues also affect data resolution and refinement. Adding complexity to the cancer cluster study is the time lag between exposure and cancer development, and there are many factors, such as lifestyle, which influence the onset of the disease.

EPA Region 6 is collaborating with CDC to examine risk hotspots and to determine if there is a potential link between disease cluster data and air toxics. This collaboration may help to expedite decisionmaking. The CDC process for targeting investigations is as follows:

- Conduct national screening using the National-Scale Air Toxics Assessment
- Utilize Regional Air Impact Modeling Initiative model to understand neighborhood-scale risk
- Conduct epidemiological screening and disease cluster analyses
- Utilize the epidemiological ground truth and National Biomonitoring Program
- Conduct an epidemiological study.

The National Biomonitoring Program measures nearly 300 environmental chemicals in blood and urine such as metals, volatile organic compounds, dioxins/furans, PAHs, polychlorinated biphenyls, and pesticides. CDC may partner with state or local entities to intervene and manage exposure situations in the event that the program detects elevated background concentrations. In such cases, the Agency for Toxic Substances and Disease Registry may also become involved and may study an area to identify possible biomarker relationships.

The purpose of an epidemiological study is to determine if a population is suffering adverse health effects from specific exposures. To be effective and accurate, an epidemiological study needs to refine the questions being asked, establish the study area/population, develop or utilize existing biomarkers to link compounds to diseases, and validate biomarkers.

Questions and Answers

The speakers had an opportunity to address questions from the audience.

A brief question and answer period addressed a range of topics. These topics included: (1) examining trends in data registries; (2) quantifying the monetary benefits (i.e., health care costs) from emission reductions; (3) deciding what contaminants should be considered for modeling; and (4) using RARE data to characterize the effects of toxics on a local level.

Appendix A: Meeting Agenda

May 16-18, 2005
Ronald Reagan Building and International Trade Center B Washington, DC

Monday, May 16, 2005

<table>
<tr><th>Time</th><th>Amphitheater</th><th>Oceanic A&B</th><th>Atrium Hall</th></tr>
<tr><td>8:30</td><td rowspan="6">Pre-Meeting Educational Session:
GEOSS and Remote Sensing Technology</td><td rowspan="6">Post-Doc Meeting
Office of Research and Development
(by invitation only)</td><td rowspan="6">Poster and Exhibit Set-Up</td></tr>
<tr><td>9:00</td></tr>
<tr><td>9:30</td></tr>
<tr><td>10:00</td></tr>
<tr><td>10:30</td></tr>
<tr><td>11:00</td></tr>
<tr><td>11:30</td><td colspan="3"></td></tr>
<tr><td>12:00</td><td colspan="3" rowspan="2">Lunch (on your own)</td></tr>
<tr><td>12:30</td></tr>
<tr><td>1:00</td><td rowspan="6">Opening Plenary
Environmental Collaborations: Nationally and Across The Globe
Dr. Charles Groat, Director, USGS
Karen Fabbri, European Commission
Randy Pomponio, EPA Region 3</td><td rowspan="6"></td><td rowspan="6">Posters Open</td></tr>
<tr><td>1:30</td></tr>
<tr><td>2:00</td></tr>
<tr><td>2:30</td></tr>
<tr><td>3:00</td></tr>
<tr><td>3:30</td></tr>
<tr><td>4:00</td><td colspan="3">Break</td></tr>
<tr><td>4:30</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3">Poster Session* and Reception
4:30 pm until
7:00 pm</td></tr>
<tr><td>5:00</td></tr>
<tr><td>7:00</td></tr>
</table>

* The Poster Session will highlight EPA research related to Collaborative Science for Environmental Solutions, allowing presenters the opportunity to quickly and efficiently communicate their research in an easy-to-view format conducive to walk-through traffic. The Poster Session will include over 225 posters and will allow participants to study the information and discuss the posters one-on-one with the presenters.

Tuesday, May 17, 2005

Time	Amphitheater	Hemisphere A	Oceanic A&B	Atrium Hall
8:00				Posters Open
	OEI Track	***ORD Track***	***Regional Track***	
8:30	Managing and Analyzing Scientific Data with IT Tools	25th Anniversary of Scientific & Technological Achievement Awards *Session 1*	How Healthy Are Our Marine Environments *Session 1*	
9:00				
9:30				
10:00	Break			Posters Open
10:30	Environmental Information for Decision Making	25th Anniversary of STA Awards *Session 2*	How Healthy Are Our Marine Environments *Session 2*	
11:00				
11:30				
12:00	Lunch (on your own)			Posters Open
12:30				
1:00				
1:30	Collaboration and Comparability in National Water Quality Monitoring Programs	Next Decade of Green Chemistry and Engineering	The Transport and Bioaccumulation of Mercury in the Environment	
2:00				
2:30				
3:00	Break			Posters Open
3:30	Use of Exchange Network Data Standards	WACAP - Impacts of Airborne Contaminants in the West	Pathogen Challenges: New Pathogens, Old Pathogens But New Challenges	Posters Down by 3:30 PM
4:00				
4:30				

Wednesday, May 18, 2005

Time	Hemisphere B	Hemisphere A	Oceanic A&B
	OEI Track	***ORD Track***	***Regional Track***
8:30	Anatomy of an Indicator	Spatial Analysis Tools and Applications	Restoration Actions and Salmon Productivity in the Pacific Northwest
9:00			
9:30			
10:00	Break		
10:30	Language and Metadata Management International Collaborative Projects	Sustainable Solutions for Restoring Degraded Ecosystems	Using Landscape Tools to Assess Vulnerability
11:00			
11:30			
12:00	Lunch (on your own)		
12:30			
1:00			
1:30	Enterprise Architecture in Action: Analysis and Tools for Decision-making in the Regions and States	Technology Verification: Collaborating for Outcomes	More than Just Hot Air: Collaborative Approaches to Cleaning Up Air Toxics Locally
2:00			
2:30			
3:00	Break		
3:30		Understanding, Assessing, and Adapting to Climate Change	
4:00			
4:30			

List of Acronyms

AED	Atlantic Ecology Division
CDC	Centers for Disease Control
CWD	Chronic Wasting Disease
ECD	Environmental Carcinogenesis Division
EPA	Environmental Protection Agency
ERD	Ecosystems Research Division
ESD	Emission Standards Division
ETV	Environmental Technology Verification
FS	Forest Service
GEOSS	Global Earth Observation System of Systems
GWERD	Ground Water and Ecosystem Restoration Division
HECD	Health and Ecological Criteria Division
IOAA	Immediate Office of the Assistant Administrator
IT	Information Technology
MED	Mid-Continent Ecology Division
MST	Microbial Source Tracking
NCEA	National Center for Environmental Assessment
NCEE	National Center for Environmental Economics
NCER	National Center for Environmental Research
NEIC	National Enforcement Investigations Center
NEPA	National Environmental Protection Act
NERL	National Exposure Research Laboratory
NHEERL	National Health and Environmental Effects Research Laboratory
NPS	National Park Service
NRMRL	National Risk Management Research Laboratory
NSF	National Science Foundation
OAQPS	Office of Air Quality Planning and Standards
OECA	Office of Enforcement and Compliance and Assurance
OEI	Office of Environmental Information
OIA	Office of International Affairs
OIC	Office of Information Collection
OPEI	Office of Policy, Economics and Innovation
OPPT	Office of Pollution Prevention and Toxics
OPPTS	Office of Prevention, Pesticides and Toxic Substances
ORD	Office of Research and Development
OSP	Office of Science Policy
OST	Office of Science and Technology
OSWER	Office of Solid Waste and Emergency Response
OTOP	Office of Technology, Operations and Planning
OW	Office of Water
OWOW	Office of Wetlands, Oceans, and Watersheds
POP	Persistent Organic Pollutant
RARE	Regional Applied Research Effort
SAB	Science Advisory Board
STAA	Scientific and Technological Achievement Awards
TRI	Toxic Release Inventory
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WACAP	Western Airborne Contaminants Assessment Program
WED	Western Ecology Division
WSWRD	Water Supply and Water Resources Division

Monday, May 16, 2005

PLENARY

Environmental Collaborations: Nationally and Across The Globe

Speakers:

Welcome and Opening Remarks - Dr. Gary Foley, EPA

Introduction of Platform Guests and Opening Remarks - Dr. Timothy Oppelt, Acting Assistant Administrator for ORD

Dr. Charles Groat, Director, United States Geological Survey

Chip Groat was sworn in as the 13th Director of the U.S. Geological Survey in November 1998. He came to this position from the University of Texas at El Paso where he was Associate Vice President for Research and Sponsored Projects following a term as Director of the Center for Environmental Resource Management. His previous experience includes Associate Director and Acting Director of the University of Texas at Austin Bureau of Economic Geology, Chairman of the Department of Geological Sciences at the University of Texas at El Paso, State Geologist and Director of the Louisiana Geological Survey, Executive Director of the American Geological Institute, and Executive Director of the LSU Center for Coastal, Energy and Environmental Resources. He has been a member of the National Research Council Board on Earth Sciences and Resources and the Outer Continental Shelf Policy Board. He is a past President of the Association of American State Geologists and of the Energy Minerals Division of AAPG. He holds a Ph.D. in Geology from the University of Texas at Austin.

Introduction - William Sonntag, EPA/OEI

Dr. Karen Fabbri, Scientific Officer for Risk Management, European Commission

Dr. Karen Fabbri obtained her undergraduate degree in Physical Geography from the University of Ottawa (Canada). She then did her post graduate studies at the International Institute for Aerospace Surveys and Earth Sciences (ITC) in the Netherlands, where she completed her MSc in Watershed Management and Conservation (use of GIS and RS for soil erosion assessment). She subsequently obtained her Ph.D. on from the Free University of Amsterdam, focusing on spatial decision support frameworks for integrated coastal zone management. She has worked in Dhaka, Bangladesh, for the Canadian International Development Agency, in Milan (Italy) as a GIS consultant for Geodan (a GIS company) , and as a researcher at the Joint Research Centre of the European Commission, in Ispra Italy. Since 1999 she has been working in Brussels as a science programme officer, initially at DG Research, and most recently at DG Information Society and Media, in the field of natural disasters, risk and emergency management. She is currently responsible for managing European research projects in the field of information and communication technologies (ICT) for disaster reduction, defining future disaster research policies, supporting related EU policies (ie: civil protection, environment, etc), and interfacing with other international initiatives (ie: UN-ISDR, UNESCO-IOC, GEOSS).

Introduction - Tom C. Voltaggio, Deputy Regional Administrator for Region 3

John ARandy@ Pomponio, Director, Environmental Assessment and Innovation Division, Region 3, US EPA

Randy Pomponio is currently the Director of the Environmental Assessment and Innovation Division. Over his more than 29 years with EPA Randy has managed the Environmental Services Division, the Waste and Chemical Management Division, served as the national expert on wetland matters, and has been instrumental in the development of collaborative, geographically based programs. His main interests are connecting science to managing for environmental results, ecosystem restoration, and innovative, collaborative approaches to environmental protection challenges.

Pre-Meeting Session

GEOSS and Remote Sensing Technology

Session Chairs: Wendy Blake-Coleman, EPA/OEI and Terrence Slonecker, EPA/ORD

Speakers:

Welcome and Overview - Wendy Blake-Coleman, EPA/OEI

Land, Water, and Air Quality Remote Sensing Overview - John Lyon, EPA/ORD

Remote Sensing and Water Quality - David Jennings, EPA/ORD

Land Cover - Remote Sensing, Visualization, and Scientific Outreach - Carolyn Offutt, EPA/OSWER

Air Quality Observations - BlueSkyRAINS - Dorsey Worthy, EPA/ORD

Collaborative Approaches Using Remote Sensing - Barry Feldman, EPA/Region 6

EPA Geospatial Data Framework - Brenda Smith, EPA/OEI

Commercial Remote Sensing Policy & Opportunities for Collaboration - Tom Cercere, USGS

The Caribbean Research Initiative: Monitoring the Health and Sustainability of Tropical Island Ecosystems - Terrence Slonecker, EPA/ORD

Earth Observations and GEOSS - Gary Foley, EPA

EPA GEO-Coordinating Committee - Near-term Opportunities for EPA - Ed Washburn, EPA/ORD and Steve Young, EPA/OEI

Open Discussion Forum - Terrence Slonecker, EPA/ORD and Deborah Mangis, EPA

TUESDAY, MAY 17, 2005

OEI TRACK

Managing Scientific Data for Effective Interactive Analysis and Decision Making
Session Chair: Robin Gonzalez, EPA/OEI/OTOP
Speakers:

- Interactive Multi-Dataset Visualization and Assimilation Challenges - Todd Plessel, Lockheed Martin
- Dr. Andrew Grimshaw, University of Virginia
- Dr. Grant Heffelfinger, Biological and Energy Science Center
- Dr. Jeffrey Kreulen, IBM-Almaden Research Facility

Environmental Information for Decision-making: What Does the Science Say?
Session Chair: Dr. Matthew Clark, EPA/ORD/NCER
Speakers:

- EPA & the Science of Information Use - Matthew Clark, EPA/ORD/NCER
- The Uses of Toxics Release Inventory Data - Gail Froiman, EPA/OEI
- The Effect of TRI Reporting Thresholds on Data Quality - Lori Bennear, Duke University
- Does Better Beach Monitoring and Notification Improve Benefits? - Julie Hewitt, EPA/OPEI/NCEE
- The Effect of Green Labels on Consumer Preferences - Mario Teisl, University of Maine
- Behavioral Responses to Ozone Alerts: Estimates of the Value of Children=s Health - Carol Mansfield, Research Triangle Institute

Collaboration and Comparability in National Water Quality Monitoring Programs
Session Chair: Chuck Spooner, EPA/OW/OWOW
Speakers:

- Developing a National Monitoring Network - Chuck Spooner, EPA/OW/OWOW
- Water Quality Data Elements to Facilitate the Exchange of Monitoring Data – LeAnne Astin, Interstate Commission on the Potomac River Basin
- Wadeable Stream Assessment Comparability Studies - Laura Gabanski, EPA/OW/OWOW
- Comparability in Analytical Methods Selection Using the National Environmental Methods Index - Eric Vowinkel, USGS, New Jersey Water Science Center

Use of Exchange Network and Data Standards to Improve and Encourage the Exchange of Data
Session Chairs: Andrew Battin, EPA/OEI and Oscar Morales, EPA/OEI
Speakers:

- Exchange Network: Background & Status - Andrew Battin, EPA/OEI
- The Environmental Sampling, Analysis and Results (ESAR) Data Standard – Oscar Morales, EPA/OEI
- The Pacific Northwest Water Quality Data Exchange - Mitch West, Oregon Department of Environmental Quality
- National Environmental Information Exchange Network: Leveraging the Infrastructure & Data Standards - Deborah Stewart, Washington Department of Ecology

ORD TRACK

25th Anniversary of Scientific and Technological Achievement Awards (Session 1)
Speakers:

- Dr. William Farland, Acting Deputy Assistant Administrator for Science
- Dr. Deborah Cory Schlechta, Chair, SAB Scientific and Technological Achievement Awards Panel
- Isolated Wetlands and Their Functions: An Ecological Perspective - Dr. Scott Leibowitz, EPA/ORD/NHEERL/WED
- Source Sink Balance and Carbon Allocation Below Ground in Plants Exposed to Ozone - Dr. Christian Andersen, EPA/ORD/NHEERL/WED
- Toxicity Characteristic Leaching Procedure and Iron Treatment of Brass Foundry Waste - Dr. Douglas Kendall, EPA/OECA/NEIC

25th Anniversary of Scientific and Technological Achievement Awards (Session 2)
Speakers:

- Methylated Trivalent Arsenicals as Candidate Ultimate Genotoxic Forms of Arsenic – Dr. Andrew Kligerman, EPA/ORD/NHEERL/ECD
- Health Effects of 'Acanthamoeba' spp. and its Potential for Waterborne Transmission – Dr. Nena Nwachuku, EPA/OW/OST/HECD
- Blood Lead Concentration and Delayed Puberty in Girls - Dr. Sherry Selevan, EPA/ORD/NCEA
- Open Discussion

Informing the Next Decade of Green Chemistry and Green Engineering Research
Session Chair: Diana Bauer, EPA/ORD/NCER
Speakers:

- Douglas Young, EPA/ORD/NRMRL
- Thomas Theis, University of Illinois, Chicago
- Richard Engler, EPA/OPPTS/OPPT
- Delcie Durham, NSF

A Large Scale, Interagency Science Project to Evaluate the Impacts of Airborne Contaminants in the West
Session Chair: Dixon Landers, EPA/ORD/NHEERL/WED
Speakers:

- Dixon Landers, EPA/ORD/NHEERL/WED
- The Pursuit for POPs in Parks - Chris Shaver, Air Resources Division, NPS
- What Makes WACAP Work?: The USGS Perspective - Donald Campbell, USGS
- What Makes WACAP Work?: The Academic Perspective - Staci Simonich, Oregon State University

REGIONS TRACK

How Healthy Are Our Marine and Estuarine Environments (Session 1)

Session Chair: Jonathan Garber, EPA/ORD/NHEERL/AED

Speakers:

- The National Coastal Report: The National Coastal Assessment: Working in Partnership with Regions, States, and Tribes to Monitor and Manage Conditions in the Coastal Ocean - Hal Walker, EPA/ORD/NHEERL/AED
- Developing Rapid Bacteria Monitoring to Protect Public Health - David Turin, EPA/Region 1
- Can We Control Urban Sprawl in the Chesapeake Bay Watershed? - Peter Claggett, USGS, Carin Bisland, EPA/Region 3/Chesapeake Bay Program, and Laura Jackson, EPA/ORD/NHEERL
- Regional Transport and Secondary Spread of Invasive Species in Pacific Coast Estuaries - Mike Blum, EPA/ORD/NERL

How Healthy Are Our Marine and Estuarine Environments (Session 2)

Session Chair: Jonathan Garber, EPA/ORD/NHEERL/AED

Speakers:

- Regional/State Application of the Invasive Species RARE Project - Joan Cabreza, EPA/Region 10
- Asian Oysters in the Chesapeake Bay - Dan Kluza, EPA/ORD/NCEA
- Overview of the Regional Methods Program: Highlights of Biological Methods Research Collaborations Between EPA Regions and ORD Laboratories - Treda Smith, EPA/OW, Teresa Norberg-King, EPA/ORD/NHEERL/MED, Margaret Pelletier, EPA/ORD/NHEERL/AED, and Maggie Passmore, EPA/Region 3
- Development of a Modeling Approach for Integrated Risk Assessment in the Marine Environment: The Example of Mercury - Elsie Sunderland and John Johnston, EPA/ORD/NERL

The Transport and Bioaccumulation of Mercury in the Environment

Session Chair: Patti Lynne Tyler, EPA/Region 8

Speakers:

- Multimedia Research on Mercury in the Everglades, Collaborations and Results - Dr. John Ackermann, EPA/Region 4
- Mercury Cycling and Risk Management Recommendations on the Cheyenne River Sioux Tribal Reservation - Dr. Dale Hoff, EPA/Region 8
- Tying it all Together: EPA Field Studies and Models Use in the Clean Air Markets Rule - Robert Ambrose, Dr. John Johnston, Chris Knightes, EPA/ORD/NERL/ERD, and Elsie Sunderland, EPA/ORD/OSP

Pathogen Challenges: New Pathogens, Old Pathogens But New Challenges

Session Chair: Dr. David Macarus, EPA/Region 5

Speakers:

- Overview of Pathogen Challenges Facing EPA - Jafrul Hasan, EPA/OW/OST
- Chronic Wasting Disease: Survival of the CWD Prions in Landfills and Waste Water Treatment - Fran Kremer, EPA/ORD/NRMRL, Susan Mooney, EPA/Region 5, Dr. Wendy O'Brien, EPA/Region 8
- The EPA MST Guide Document - Mark Rodgers, EPA/ORD/NRMRL/WSWRD
- The NEEAR Study: Can Faster Methods of Measuring Recreational Water Help Prevent Swimming Associated Illness? - Tim Wade, EPA/ORD/NHEERL
- Control of West Nile Virus in New York: Collaborations of EPA Region 2, CDC and NY Dept. of Health - Michael Kramer, EPA/Region 2

WEDNESDAY, MAY 18, 2005

OEI TRACK

Anatomy of an Indicator

Session Chair: Heather Case, EPA/OEI and Denice Shaw, EPA/ORD

Speakers:

Heather Case, EPA/OEI

Denice Shaw, EPA/ORD

The Air Quality Index: A Simple and Effective Indicator - Richard Wayland, EPA/OAQPS

Using the Air Quality Index on a Local Level - Randy Mosier, Maryland Department of the Environment

Index Development and Scaling - Challenges and Opportunities - Jay Messer, EPA/ORD

Language and Metadata Management International Collaborative Projects

Session Chair: William Sonntag, EPA/OEI

Speakers:

Larry Fitzwater, EPA/OEI/OIC

Ecoterm: An International Initiative for Environmental Terminology Sharing - Gail Hodge, National Biological Information Infrastructure, U.S. Geological Survey / Information International Associates, Inc.

Dr. David Stanners, Strategic Development and International Cooperation, European Environment Agency

Enterprise Architecture in Action: Analysis and Tools for Decision-making in the Regions and States

Session Chairs: Ming Chang, EPA/OEI and Megan Quinn, EPA/OEI

Speakers:

John Sullivan, EPA/OEI

The Science Portal - An Enterprise Approach to Science and Collaboration - Jacques Kapuscinski and Terry Grady, EPA/ORD

Analysis and Tools for Decision-making: Collaborating and Coordinating with Regions and States - Ming Chang, EPA

Elsie Sunderland, EPA

ORD TRACK

Spatial Analysis Tools and Applications for Environmental Assessments and Management

Session Chairs: K. Bruce Jones, EPA/ORD/NERL and Luis Fernandez, EPA/OIA

- Introduction - Luis Fernandez, EPA/OIA
- Program to Assist in Tracking Critical Habitat (PATCH) - Nathan Schumaker, EPA/ORD/NHEERL
- NEPAssist - Harvey Simon, EPA/Region 2
- Mid-west Geospatial Partnership - Richard Zdanowicz, EPA/Region 5
- Analytical Tool Interface for Landscape Assessments (ATtILA) - Donald Ebert, EPA/ORD/NERL
- Automated Geospatial Watershed Assessment (AGWA) - William Kepner, EPA/ORD/NERL

Sustainable Solutions for Restoring Degraded Watersheds and Riparian Ecosystems: Implementation, Evaluation, and Amelioration

Session Chair: Joseph Williams, EPA/ORD/NRMRL/GWERD

Speakers:

- Session Overview - Joseph Williams, EPA/ORD/NRMRL/GWERD
- Jennifer Newland and Michael Strager, Canaan Valley Institute
- Restoring Great Basin Riparian Ecosystems - A Collaborative, Interdisciplinary FS and EPA Project - Jeanne Chambers, USDA/Forest Service
- Importance of EPA Ecosystem Research to Environmental Management Programs in Baltimore County, MD - Donald Outen, Baltimore County Department of Environmental Protection and Resource Management
- Paul Mayer, EPA/ORD/NRMRL/GWERD

The Environmental Technology Verification Program: Collaborating for Outcomes

Session Chair: Teresa Harten, EPA/ORD/NRMRL/ETV Program

Speakers:

- Environmental Technology Verification Program Update - Teresa Harten, EPA/ORD/NRMRL/ETV Program
- Diesel Engine Retrofit Technologies - Evelyn Hartzell, EPA/ORD/NRMRL/ETV Program and Dennis Johnson, EPA/Office of Transportation and Air Quality
- Ambient Ammonia Monitors - Tom Kelly, Battelle
- Arsenic Drinking Water Treatment Systems - Jeff Adams, EPA/ORD/NRMRL/ETV Program and Bruce Bartley, NSF International
- Ballast Water Treatment Technologies - Ray Frederick, EPA/ORD/NRMRL/ETV Program and Kathleen Moore, US Coast Guard

Public-Private Partnerships to Understand, Assess, and Adapt to Climate Change

Session Chair: Dr. Joel Scheraga, EPA/ORD/IOAA

Speakers:

- Dr. Dan Loughlin, EPA/ORD/NRMRL and Dr. Gary Kleiman, Northeast States for Coordinated Air Use Management
- Coral Condition and Global Change: Assessment Tools for Resource Management – Dr. William Fisher, EPA/ORD/NHEERL
- Decision Support for Managing Wildland Fire Risk - Dr. Barbara Morehouse, Institute for the Study of Planet Earth, University of Arizona
- Protecting Our Water As Climate Changes - John Furlow, EPA/ORD/NCEA
- Dr. Arnold Vedlitz, Institute of Science, Technology and Public Policy, Texas A&M University

REGIONS TRACK

Evaluation of the Relationship between Aquatic Habitat Restoration Actions and Salmon Productivity in Pacific Northwest Watersheds

Session Chair: Dr. Derek Poon, EPA/Region 10

Speakers:

Dr. Robert Bilby, Weyerhaeuser Company

Dr. William Ehinger, Washington State Department of Ecology

Dr. Christopher Jordan, National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center

Using Landscape Tools to Assess Vulnerability

Session Chair: Brenda Groskinsky, EPA/Region 7

Speakers:

Brenda Groskinsky, EPA/Region 7

Use of Landscape Tools for the Upper White River Basin - Jaci Ferguson, EPA/Region 7

Dr. Ricardo Lopez, EPA/ORD/NERL/ESD

More than Just Hot Air: Collaborative Approaches to Cleaning Up Air Toxics Locally

Session Chair: Mike Callahan, EPA/Region 5

Speakers:

Getting Some Air Time: The Challenges of Air Toxics - Sean Hogan, EPA/Region 9

AThis Air Is Killing Me!@: Everyday Activities and Their Effects on Real People - Characterizing Air Emissions Through ORD=s RARE Program - Sean Hogan, EPA/Region 9

Sniffing Out Sources: Air Toxics Analysis Goes High Tech - Remote Sensing and Infrared Hand-Held Devices for Determining Leaks from Barges or Railroad Cars - Barry Feldman, EPA/Region 6

But What Does This Mean in the Real World?: The Local Approach to Air Toxics Risk Assessment - Setting Priorities by Linking Modeled Air Toxics Concentrations to Community Health Effects - Jeff Yurk, EPA/Region 6